ASSEMBLING AND USING YOUR......

Heathkit

AMATEUR TRANSMITTER
MODEL AT-1

595-64

HEATH COMPANY
BENTON HARBOR, MICHIGAN

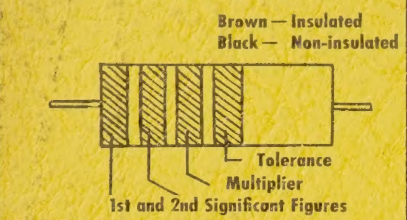
PRICE $1.00

THE WORLD'S *Finest* TEST EQUIPMENT IN KIT FORM

STANDARD COLOR CODE — RESISTORS AND CAPACITORS

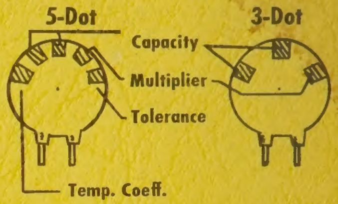
INSULATED UNINSULATED Color	FIRST RING BODY COLOR First Figure	SECOND RING END COLOR Second Figure	THIRD RING DOT COLOR Multiplier
BLACK	0	0	None
BROWN	1	1	0
RED	2	2	00
ORANGE	3	3	,000
YELLOW	4	4	0,000
GREEN	5	5	00,000
BLUE	6	6	000,000
VIOLET	7	7	0,000,000
GRAY	8	8	00,000,000
WHITE	9	9	000,000,000

AXIAL LEAD RESISTOR

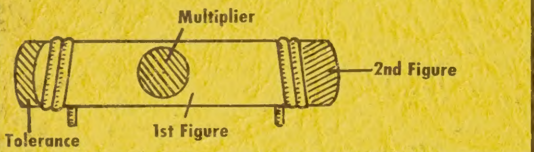


Wire wound resistors have 1st digit band double width

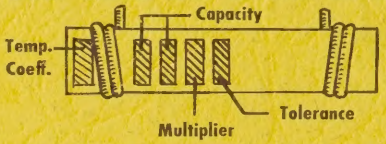
DISC CERAMIC RMA CODE



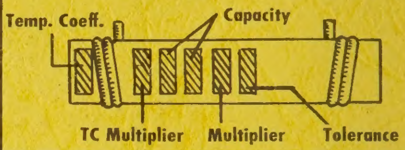
RADIAL LEAD DOT RESISTOR



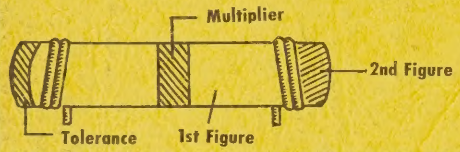
5-DOT RADIAL LEAD CERAMIC CAPACITOR



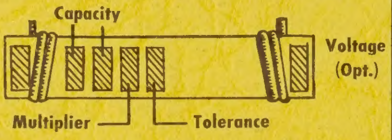
EXTENDED RANGE TC CERAMIC HICAP



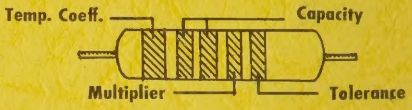
RADIAL LEAD (BAND) RESISTOR



BY-PASS COUPLING CERAMIC CAPACITOR



AXIAL LEAD CERAMIC CAPACITOR

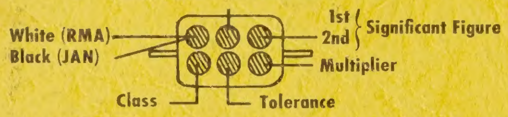


The standard color code provides all necessary information required to properly identify color coded resistors and capacitors. Refer to the color code for numerical values and the zeroes or multipliers assigned to the colors used. A fourth color band on resistors determines tolerance rating as follows: Gold = 5%, silver = 10%. Absence of the fourth band indicates a 20% tolerance rating.

The physical size of carbon resistors is determined by their wattage rating. Carbon resistors most commonly used in Heathkits are ½ watt. Higher wattage rated resistors when specified are progressively larger in physical size. Small wire wound resistors ½ watt, 1 or 2 watt may be color coded but the first band will be double width.

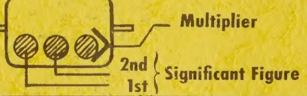
MOLDED MICA TYPE CAPACITORS

CURRENT STANDARD CODE

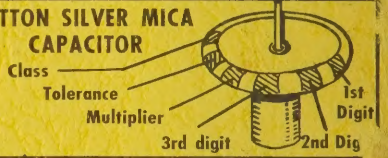


JAN & 1948 RMA CODE

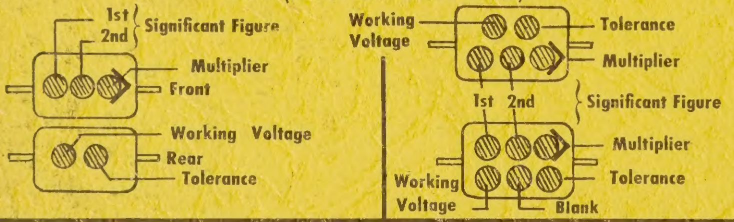
RMA 3-DOT (OBSOLETE) RATED 500 W.V.D.C. ± 20% TOL.



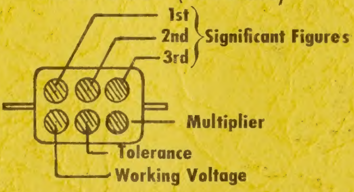
BUTTON SILVER MICA CAPACITOR



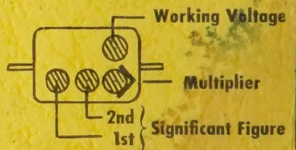
RMA (5-DOT OBSOLETE CODE)



RMA 6-DOT (OBSOLETE)

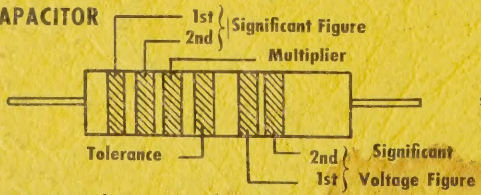


RMA 4-DOT (OBSOLETE)



MOLDED PAPER TYPE CAPACITORS

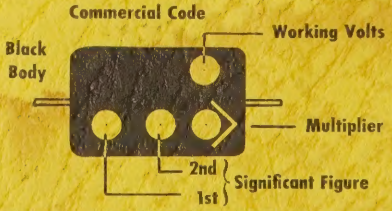
TUBULAR CAPACITOR



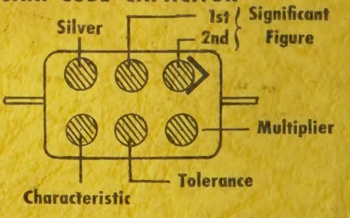
Normally stamped for value

A 2 digit voltage rating indicates more than 900 V. Add 2 zeros to end of 2 digit number.

MOLDED FLAT CAPACITOR



JAN. CODE CAPACITOR



The tolerance rating of capacitors is determined by the color code. For example: red = 2%, green = 5%, etc. The voltage rating of capacitors is obtained by multiplying the color value by 100. For example: orange = 3 × 100 or 300 volts. Blue = 6 × 100 or 600 volts.

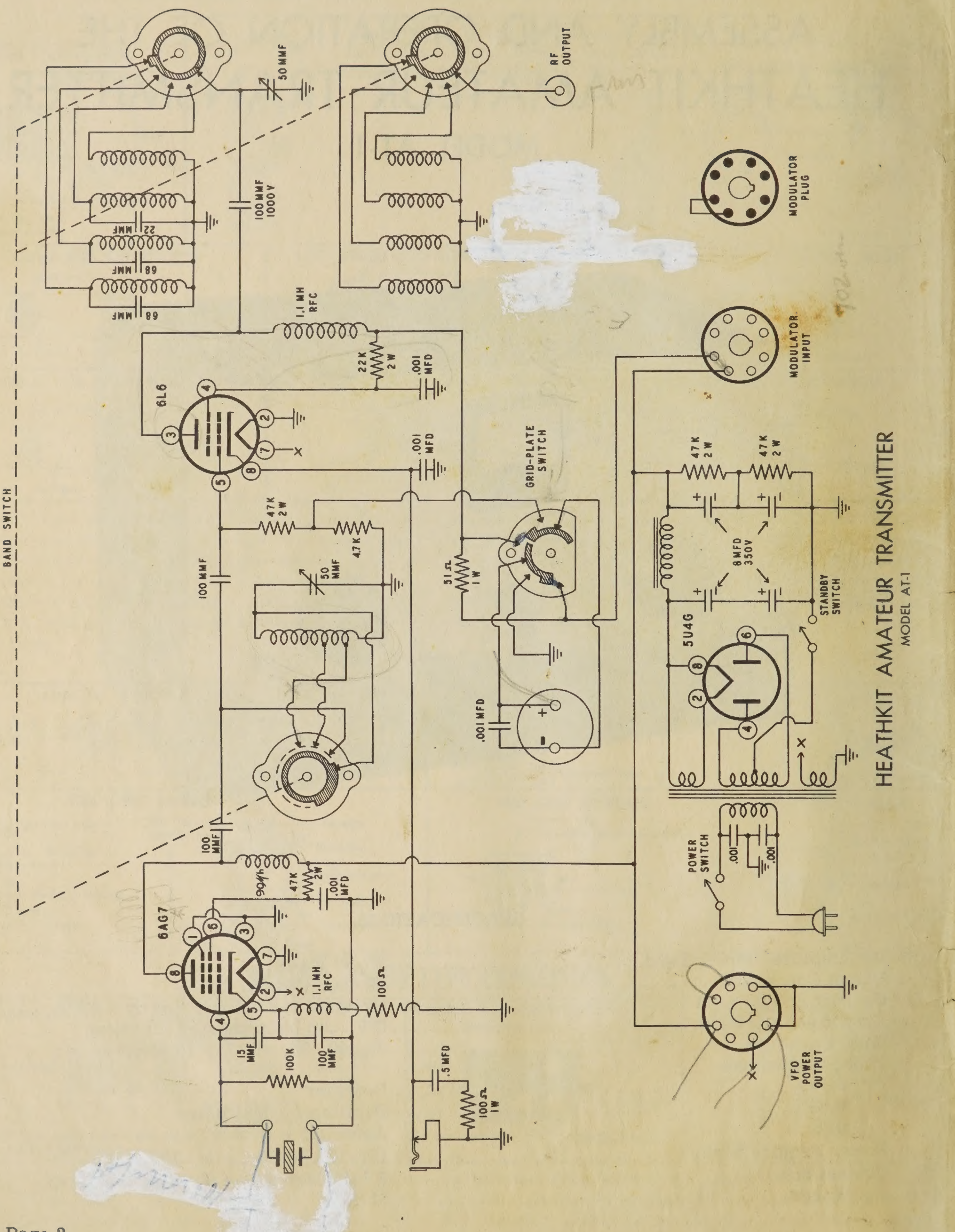
In the design of Heathkits, the temperature coefficient of ceramic or mica capacitors is not generally a critical factor and therefore Heathkit manuals avoid reference to temperature coefficient specifications.

Courtesy of Centralab

ASSEMBLY AND OPERATION OF THE
HEATHKIT AMATEUR TRANSMITTER
MODEL AT-1

SPECIFICATIONS

RF Amplifier Power Input	25-30 Watts
Output Connection	52 Ohm Coaxial Cable
Oscillator Operation	Crystal, can be operated by a VFO
Amplifier Operation	CW, can be modulated for phone
Band Coverage	80, 40, 20, 15, 11, 10 Meters
Tube Complement	
5U4G	Rectifier
6AG7	Oscillator - Multiplier
6L6	Amplifier - Doubler
Power Requirements	105-125 50/60 Cycle, 100 Watts
Cabinet Size	8 1/8" high x 13 1/8" wide x 7" deep
Net Weight	13 lbs.


HEATHKIT AMATEUR TRANSMITTER
MODEL AT-1
BAND SWITCH
RF OUTPUT
50 MMF
100 MMF 1000V
22 MMF
68 MMF
68 MMF
1.1 MH RFC
22 K 2 W
.001 MFD
6L6
.001 MFD
GRID-PLATE SWITCH
47 K 2 W
47 K
100 MMF
50 MMF
51 Ω 1 W
.001 MFD
100 MMF
6AG7
47 K 2W
.001 MFD
1.1 MH RFC
100 Ω
15 MMF
100 K
100 MMF
.5 MFD
100 Ω 1 W
MODULATOR PLUG
MODULATOR INPUT
47 K 2 W
47 K 2 W
8 MFD 350V
STANDBY SWITCH
5U4G
POWER SWITCH
.001
.001
VFO POWER OUTPUT

INTRODUCTION

The Heathkit Model AT-1 Transmitter was designed to provide both the beginning and experienced amateur with a simply constructed yet versatile kit form transmitter at modest cost. Consideration was also given to the probable enlarging of the operator's station. Rather than become obsolete, the AT-1 can be operated with crystal or VFO control and used as an all-band exciter for a high power final. It has provision for modulation as a low power phone transmitter and can be used directly as such or used to drive a linear amplifier in a high power phone station. For the "old timer," it makes an excellent standby transmitter while the big "rig" is being overhauled.

The transmitter incorporates the maximum permissible shielding to minimize TVI from harmonics radiated directly by the transmitter. The amplifier stage operates as a doubler on the higher frequencies to eliminate the possibility of parasitic oscillations.

Although primarily designed for crystal operation, it will perform equally well when driven by a VFO and is equipped to supply the VFO with both plate and filament power from an octal socket on the rear of the transmitter chassis. The band switching knob on the panel switches both the oscillator and amplifier coils simultaneously. This not only increases the convenience of operation but also lessens the possibility of operation on the wrong crystal or VFO harmonic. A three position meter switch provides for measurement of the amplifier grid current, amplifier plate current, and has an "off" position for use when the transmitter is being keyed.

The transmitter incorporates tried and proven tube types and circuitry, careful layout, and quality components. It will give long and reliable service when properly constructed.

CIRCUIT DESCRIPTION

The power supply is conventional. A transformer steps up the AC line voltage to approximately 400 volts, which is then converted to direct current by the action of a 5U4G full-wave rectifier tube. Ripple component present in the output of the rectifier is removed by a "brute force" filter consisting of four electrolytic condensers and a filter choke. A switch in the AC line turns the transmitter ON and OFF. Another switch in the negative return shuts off the DC power when in the STANDBY position, leaving the filaments on.

The crystal oscillator consists of a 6AG7 tube operated in a tuned or untuned Colpitts circuit. The plate circuit of the oscillator is untuned when the transmitter is operated on the 80 meter band. This prevents coupling between oscillator and amplifier coils when both are at the same frequency. On all other bands the oscillator is operated as a tuned plate amplifier or doubler stage. One set of contacts on the band switch inserts the proper oscillator coil for each band. Grid bias for the 6AG7 is obtained mainly from a grid leak resistor and partially from resistance in the cathode circuit.

The output stage consists of a 6L6 amplifier-doubler which may be operated up to approximately 30 watts input on CW or Phone. Four coils each having preadjusted antenna coupling loops are connected in turn to the 6L6 plate circuit by the action of the band switch. These coils cover the frequency range from 3.5 to 30 mc. Bias for this stage is derived from the grid current flowing through the grid resistor and is only present when the stage is being excited by the oscillator. The Grid-plate meter has its full scale sensitivity automatically changed from 10 to 100 milliamperes when switched from the grid to plate position.

Two octal sockets on the rear of the chassis provide connections for audio input and VFO power output. A coaxial jack, when used with 52 ohm coax cable, provides a shielded RF output to the antenna coupler. A .5 μfd condenser and a 100 Ω resistor across the key jack provide an effective key click filter.

NOTES ON ASSEMBLY AND WIRING

The Heathkit Model AT-1 Amateur Transmitter, when constructed in accordance with the instructions in this manual, is a high quality reliable means of communication capable of years of trouble-free service. We therefore urge you to take the necessary time to assemble and wire the kit carefully. Do not hurry the work and you will be rewarded with the pride that comes from DX contacts with a self-constructed transmitter.

This manual is supplied to assist you in every way to complete the transmitter with the least possible chance for error. We suggest that you take a few minutes now and read the entire manual through before any work is started. This will enable you to proceed with the work much faster when construction is started. The large fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the completion of the kit. These diagrams are repeated in smaller form within the manual. We suggest that you retain the manual in your files for future reference, both in the use of the transmitter and for its maintenance.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you to identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

Read the note on soldering on the inside of the back cover. Crimp all leads tightly to the terminal before soldering. Be sure both the lead and the terminal are free of wax, corrosion, or other foreign substances. Use only the best rosin core solder, preferably a type containing the new activated fluxes, such as Kester "Resin-Five," Ersin "Multicore," or similar types.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

Resistors and condensers generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on condensers are generally even greater. Limits of +100% and -50% are common for electrolytic condensers. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished transmitter.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are carefully checked before they are approved, and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you may find that a 2.2 megohm resistor has been supplied in place of a 2 megohm as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion in checking the contents of your kit.

We strongly urge that you follow the wiring and parts layout shown in this manual. The position of wires and parts is extremely critical in a high frequency transmitter, and changes may seriously affect the characteristics of the circuit.

The following instructions are presented in a simple, logical, step-by-step sequence to enable you to complete your kit with the least possible confusion.

Be sure to read each step all the way through before starting. When a step is completed, check it off in the space provided. This makes it easy to resume construction after your work has been interrupted.

NOTE: We suggest that you do the following before any work is started:

1. Select from the large fold-in pictorials included with the manual the diagram showing the phase of construction you are engaged in at the time. Attach this diagram to the wall above your work space.
2. After identifying the parts from the parts list, lay them out in a large shallow box so that they are readily accessible. This will save considerable time in construction.
3. Read thoroughly the assembly and wiring instructions on the inside rear cover of the manual and refer to the general information on both inside covers of the manual to identify the parts.
4. In assembling the kit, use lockwashers under all nuts unless a solder lug is used. Tube sockets are mounted with the metal flange inside the chassis. All screws have their heads on top or outside of the chassis. This construction may be noted by referring to Figure 1. Unless otherwise stated, 6-32 screws, lockwashers and nuts are used in mounting of parts.

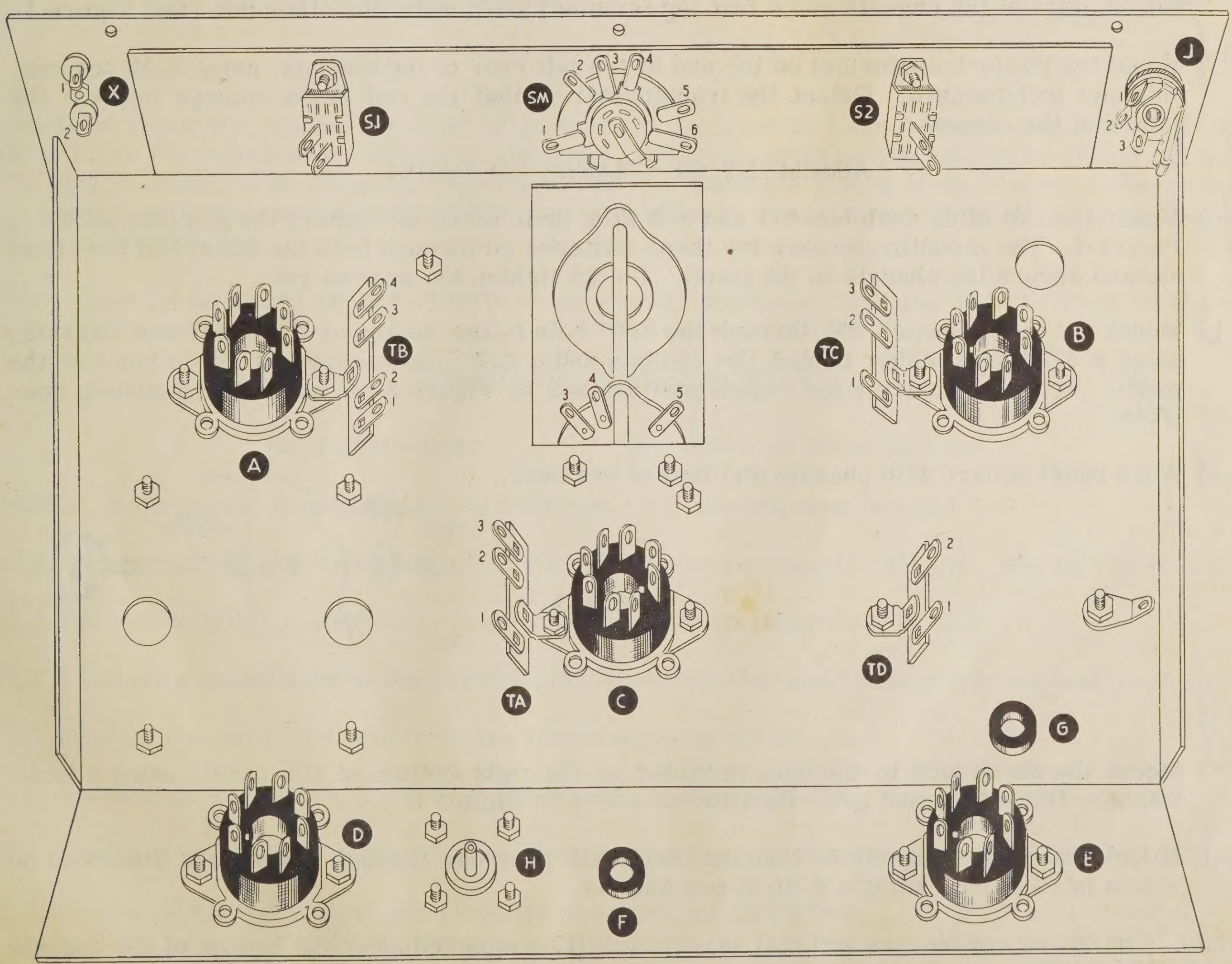


Fig. 1

( ) Mount an octal socket in hole A with the keyway toward the center of the chassis. At the same time mount a four-lug terminal strip under the chassis, using the mounting screw nearest the center of the chassis. As previously stated, 6-32 screws, lockwashers and nuts are used in mounting all parts unless otherwise specified.

( ) Mount an octal socket in hole B with the keyway toward the center of the chassis. At the same time, mount a three-lug terminal strip under the chassis and a solder lug on top of the chassis, using the mounting screw nearest the center of the chassis as shown in Figures 1 and 2.

( ) Mount an octal socket in hole C with the keyway toward the right side of the chassis when viewed from the rear and a three-lug terminal strip mounted on the left hand mounting screw. Refer to Figure 1.

( ) Mount two octal sockets in holes D and E with their keyways as shown in Figure 1.

( ) Insert 3/8" rubber grommets in holes F and G.

( ) Mount the coaxial output jack in hole H using 4-40 screws and nuts.

( ) Mount the filter choke on top of the chassis with the leads over the grommet G using the two mounting holes at the right rear of the chassis. Place a solder lug under the nut nearest the edge of the chassis and a two-lug terminal strip under the other nut. See Figure 1.

( ) Mount the power transformer on top and at the left rear of the chassis, using 8-32 screws, nuts and lockwashers. Orient the transformer so that the red leads emerge nearest the center of the chassis.

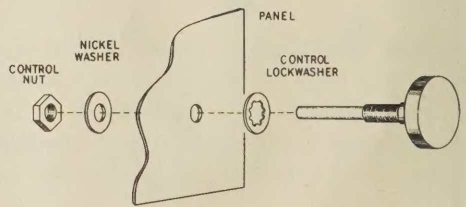
ASSEMBLY OF CHASSIS TO PANEL

( ) Mount the two slide switches S-1 and S-2 with their terminal lugs in the position shown in Figure 1. The mounting screws for these switches go through both the panel and the chassis and secure the chassis to the panel. Do not tighten the screws yet.

( ) Mount the meter switch SM through the 3/8" hole in the center of the panel and chassis, using a 3/8" lockwasher behind the chassis and a 3/8" flatwasher and nut in front of the panel. Refer to Figure 1 for switch position and to Figure 3 for method of mounting controls.

( ) Align panel square with chassis and tighten screws.

Fig. 3



HOW TO MOUNT CONTROLS & SWITCHES

( ) Mount the phone jack in the hole provided at the right bottom of the panel, using a lockwasher, flatwasher and nut. Position as shown in Figure 1.

( ) Mount the crystal holder so that the terminals protrude through the back of the panel as shown in Figure 1, using a 4-40 screw and nut.

Note: The tuning condensers and coil assembly will be mounted after the bottom of the chassis has been wired.

WIRING OF THE AT-1 TRANSMITTER

NOTE: Before beginning the wiring, refer again to the notes on wiring and soldering on the inside rear cover of the manual. We cannot stress too strongly the importance of careful wiring and soldering when applied to radio frequency circuits. In building this transmitter, you will use a considerable amount of heavy tinned wire. Both from the standpoint of neatness and efficiency, the leads should be kept short and straight. Sharp bends are to be avoided when possible and RF leads in the grid and plate circuits should be isolated as far as possible from other circuits and from each other. Soldering should be done with a great deal of care so that fluxes will not run over onto adjacent insulation; thus causing leakage and a possible loss of power.

Components are given code designations so that identification of parts on both the diagrams and on the written matter is easily defined. The tube sockets are numbered A to E inclusive and correspond to the mounting holes referred to previously under assembly instructions. It is recommended that the tube sockets be marked in pencil on the bottom of the chassis, A to E.

Switches are designated as S-1, S-B, etc. Other parts are referred to in a similar manner which will be readily apparent as the work progresses. Octal sockets are numbered in a clockwise direction, starting from the left of the keyway when viewed from the bottom. The grounding lugs attached to the sockets are numbered in the same way. See Figure 4.

Thus a connection to B5 means terminal 5 counted in a clockwise direction from the keyway on socket B. Similarly, AG-3 is the number 3 ground lug measured in the same manner on socket A.

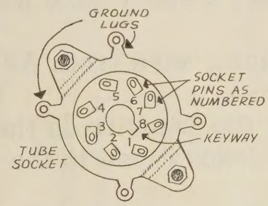


Fig. 4

Leads on resistors, condensers and transformers are generally much longer than they need to be to make the indicated connections. In these cases, the excess leads should be cut off before the part is added to the chassis. Not only does this make the wiring much neater, but in radio frequency work the excess length of the lead may actually create tuned parasitic circuits at undesired frequencies.

Wire is to be insulated unless otherwise specified. Insulated sleeving is to be used on bare wires when called for.

WIRING OF POWER SUPPLY

(S) means solder. (NS) means do not solder yet.

NOTE: Refer to the schematic and to Pictorial 1 for the following wiring.

(✓) Connect a .001 μfd condenser from TA1 (NS) (use sleeving) to CG1 (S). See Pictorial 1.

(✓) Connect a .001 μfd condenser from TA2 (NS) (use sleeving) to CG4 (S).

(✓) Twist the red leads from the power transformer together and connect one red lead to C4 (S).

(✓) Connect the other red lead from the transformer to C6 (S).

(✓) Connect the red-yellow lead from the transformer to C7 (NS).

(✓) Twist the yellow leads from the transformer together and connect one yellow lead to C2 (S).

(✓) Connect the other yellow lead from the transformer to C8 (NS).

(✓) Twist the green leads from the transformer together and connect one green lead to D2 (NS).

( ) Connect the other green lead from the transformer to DG4 (NS).

( ) Twist the black leads from the transformer together and connect one black lead to TA1 (NS).

( ) Connect the other black lead to TA2 (NS).

( ) Twist together two pieces of hookup wire about 7" long. Strip the insulation from one pair of ends and connect to the terminals of S1 (S).

( ) Run the twisted pair of leads close to the chassis to terminals TA2 and TA3. Cut wire to proper length and connect either one to TA2 (S) and the other to TA3 (NS).

( ) Connect a lead from A2 (NS) to D2 (S).

( ) Run a piece of light bare wire from D1 (S) through D7 (S) to DG4 (S).

( ) Connect a wire from C7 (S) to either terminal on switch S2 (S).

( ) Connect a wire from the other switch terminal (S) to J2 (NS) on the phone jack.

( ) Connect a short bare wire from J2 (S) to J3 (S).

( ) Connect a wire from A2 (S) to B7 (S).

( ) Twist the leads from the filter choke together and pass them through the grommet G. Run these leads close to the back edge of the chassis over to the socket C.

( ) Connect one lead of the choke to C8 (NS).

( ) Connect the other lead to C3 (NS).

Note: In wiring the following condensers, cut the leads to a length that will allow the condensers to fit snugly between their connection points. See Pictorial 1.

( ) Connect the positive lead of an 8 μfd 350 volt condenser to C8 (S). The positive lead will have the word POSITIVE or PLUS markings on that end of the condenser case. Connect the other lead of this condenser to TD2 (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to TD2 (S).

( ) Connect the other lead of this condenser to the solder lug near the chassis edge (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to C3 (NS).

( ) Connect the other lead of this condenser to TD1 (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to TD1 (NS).

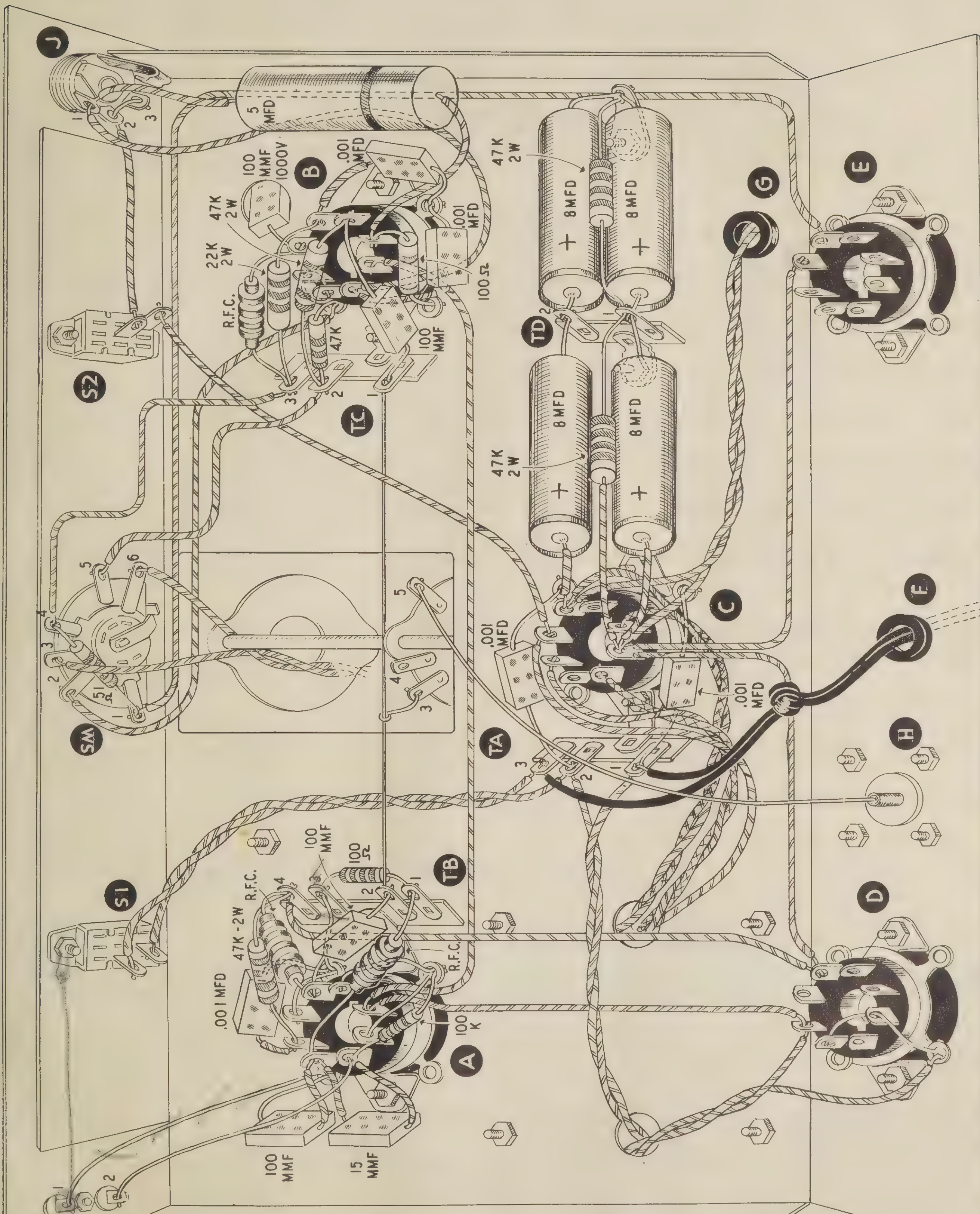
( ) Connect the other lead of this condenser to the solder lug near the chassis edge (NS).

( ) Connect a 47 KΩ 2 watt resistor between C3 (NS) and TD1 (NS).

( ) Connect a 47 KΩ 2 watt resistor between TD1 (S) and the solder lug at the edge of the chassis (S).

( ) Connect a wire from C3 (NS) to D4 (NS).

( ) Connect a wire from C3 (S) to E3 (S).



J
5 MFD
.001 MFD
100 MMF 1000V
B
47K 2W
22K 2W
R.F.C.
4.7K
100 MMF
100 Ω
.001 MFD
47K 2W
8 MFD
8 MFD
G
E
TD
S2
T.C.
47K 2W
8 MFD
8 MFD
SW
5 Ω
.001 MFD
C
.001 MFD
F
TA
H
S1
TB
100 MMF
100 Ω
R.F.C.
47K-2W
.001 MFD
R.F.C.
100 K
A
D
100 MMF
15 MMF
X

PICTORIAL 1

( ) Connect one end of a wire about 16" long to E4 (S).

( ) Run the wire around the outside edge of the chassis as shown in Pictorial 1 and connect the other end to SM1 (NS). Refer to Figure 1 or Pictorial 1 for SM1 connection.

This completes the power supply wiring.

WIRING OF THE OSCILLATOR TUBE

Note: For best operation and ease of construction, parts should be placed as shown in Pictorial 1.

( ) Connect a wire from D4 (S) to TB4 (NS).

( ) Connect a piece of light bare wire to A3 (S). Pass the wire through AG1 (NS) to A1 (S).

( ) Connect a 100 KΩ resistor from A4 (NS) to AG1 (S).

( ) Connect a piece of light bare wire from A7 (S) to AG4 (NS).

CAUTION: Do not use 6 1/2" length of heavy bus wire until called for.

( ) Connect a heavy bare wire from X1 (S) to AG3 (NS). See Pictorial 1.

( ) Connect a .001 μfd mica condenser from A6 (use sleeving) (NS) to AG4 (NS).

( ) Connect one end of a 100 μμf mica condenser to AG3 (S). Connect the other end to A5 (NS). (Use sleeving.)

( ) Connect one end of a 15 μμf mica condenser to A5 (NS). (Use sleeving.) Connect the other end to A4 (NS). (Use sleeving.)

( ) Connect a heavy bare wire from X2 (S) to A4 (S). See Pictorial 1.

( ) Connect an RF choke from A5 (S) to TB1 (NS).

( ) Connect a 100 Ω 1/2 watt resistor from TB1 (S) to TB3 (NS).

Note: At this point, the builder has two choices in the method of keying the transmitter. In the interest of stability, it is recommended that only the amplifier stage be keyed. However, it may be wired so that both the amplifier and oscillator stage can be keyed simultaneously for break-in operation. If it is desired to key only the amplifier, connect a short bare wire from TB3 (S) to AG4 (S). If both stages are to be keyed, connect a .001 μfd condenser from TB3 (NS) to AG4 (S) in place of the bare wire; then, connect a wire to TB3 (S). Run this wire along the front edge of the chassis to J1 (NS). All wiring instructions that follow apply for either method of keying.

( ) Connect a 47 KΩ 2 watt resistor from A6 (S) to TB4 (NS).

( ) Connect the single pi 90 μh RF choke from A8 (NS) to TB4 (S).

( ) Connect a 100 μμf mica condenser from A8 (S) to TB2 (NS).

This completes the oscillator tube wiring.

AMPLIFIER TUBE WIRING

(✓) Connect a light bare wire from B1 (S). Pass the wire through B2 (S) to BG1 (NS).

(✓) Connect a 4.7 KΩ resistor from TC2 (NS) to BG1 (NS).

(✓) Connect a .001 μfd mica condenser from BG3 (NS) to B4 (NS). (Use sleeving.)

(✓) Connect a .001 μfd mica condenser from BG3 (S) to B8 (NS). (Use sleeving.)

(✓) Connect a wire from B8 (S) to J1 (NS).

(✓) Connect the outside foil of a .5 μfd paper condenser to B6 (NS). (Use sleeving.) See Pictorial 1 for mounting position.

(✓) Connect the other end of the condenser to J1 (S). (Use sleeving.)

(✓) Connect a 100 Ω 1 watt resistor from B6 (S) to BG4 (S).

(✓) Connect a 100 μμf mica condenser from TC1 (NS) to B5 (NS).

(✓) Connect a 47 KΩ 2 watt resistor from B5 (S) to TC2 (NS).

(✓) Connect a wire from TC2 (S) to SM5 (S).

(✓) Connect a wire from SM2 (S) to BG1 (S). Run the wire along the front of the chassis.

(✓) Connect a 22 KΩ 2 watt resistor from B4 (S) to TC3 (NS).

(✓) Connect a 100 μμf 1,000 volt mica condenser to B3 (NS). Pass this condenser through the hole in the chassis adjacent to the tube socket so that the insulated part of the condenser is centered in the hole. Leave the other end free. See Pictorial 1.

(✓) Connect an RF choke between B3 (S) and TC3 (NS).

(✓) Connect a wire from TC3 (S) to SM4 (NS).

( ) Connect a 51 Ω 1 watt 5% resistor from SM1 (S) to SM4 (S).

This completes the amplifier wiring.

COIL ASSEMBLY AND WIRING

(✓) Mount the oscillator coil as shown in Figure 2 placing a solder lug under the head of the screw. Use a lockwasher and nut on the underside of the chassis.

(✓) Mount the oscillator and amplifier variable tuning condensers CO and CA on the panel as shown in Figure 2, using round head 6-32 screws.

(✓) Examine Pictorial 2 carefully, noting the terminal positions of the band switch SB and mount on the panel as shown in Pictorial 2 omitting the lockwasher. Use a flatwasher and nut on the front of the panel and do not tighten the nut yet.

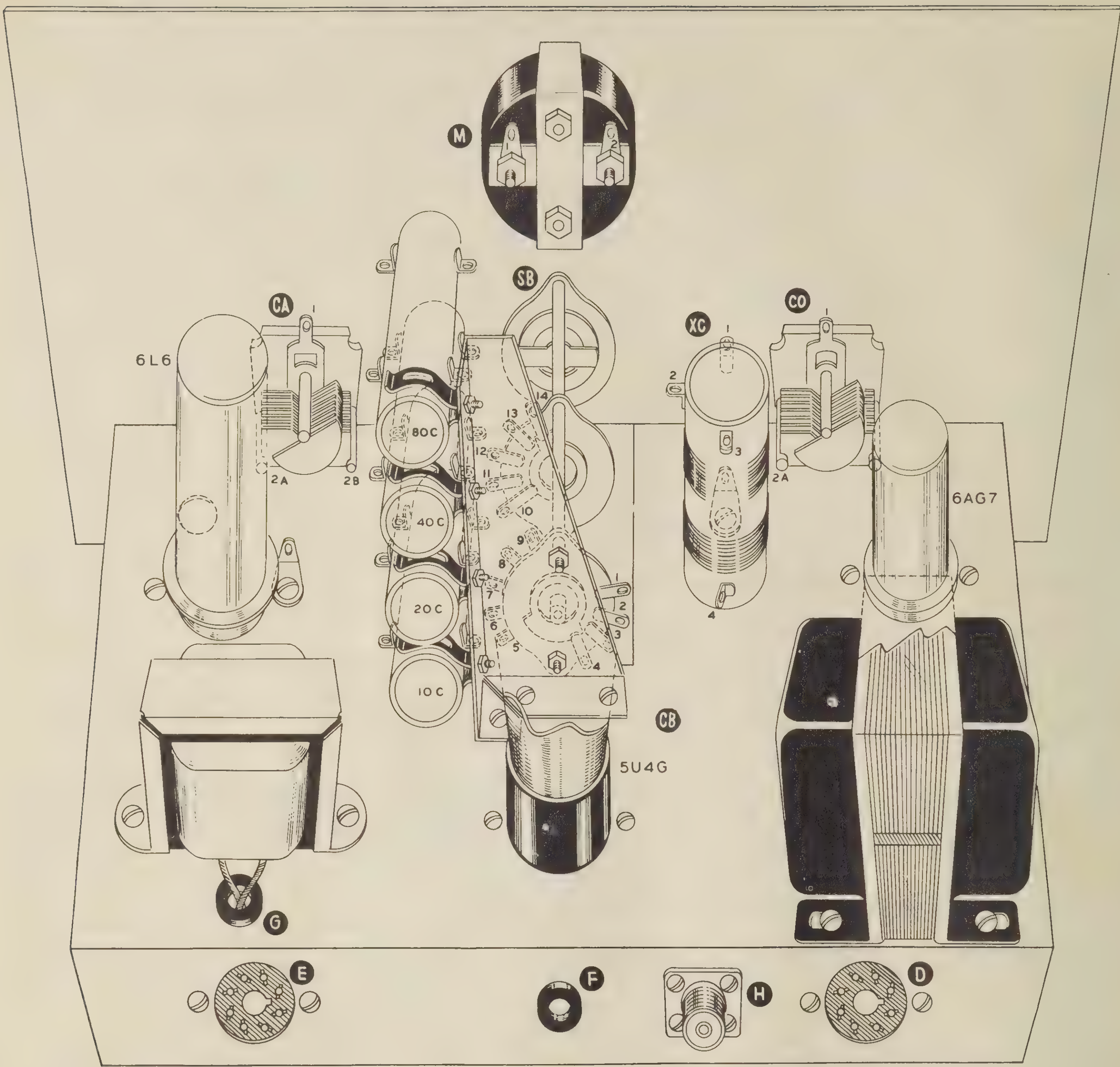


Fig. 2

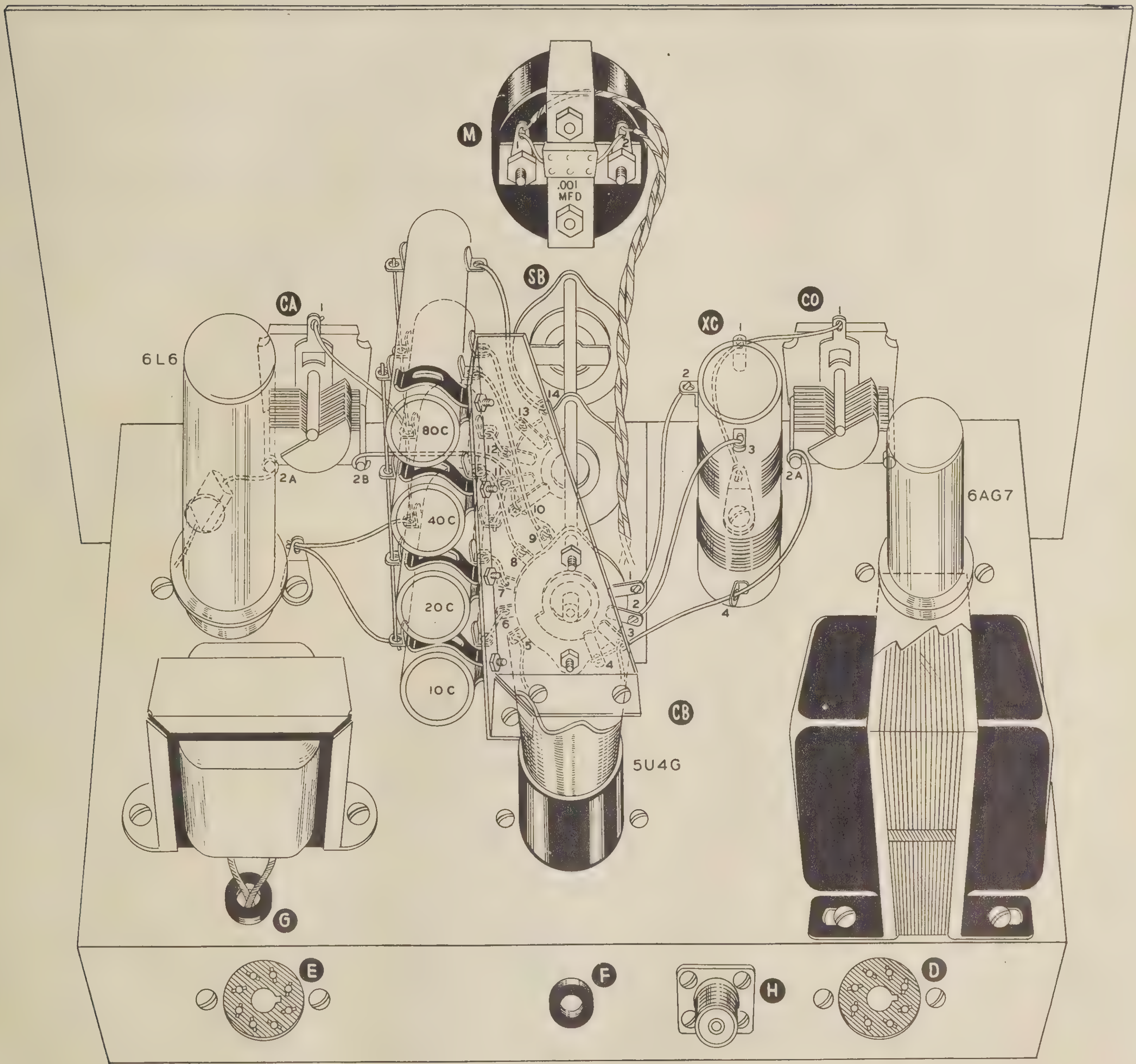
( ) By referring to Figure 2 and Pictorial 2, you will note that the coil bracket CB anchors the rear end of the band switch as well as supporting the amplifier coils. Slide the holes in the flat portion of the coil bracket over the two screws protruding from the rear of the band switch and secure using 5-40 nuts and lockwashers furnished.

( ) Now align the three holes in the base of the coil bracket with the holes in the chassis and mount the coil bracket to the chassis using 6-32 screws, nuts, and lockwashers.

( ) Tighten the 3/8" band switch nut.

( ) Mount the four coil clamps on the coil bracket as shown in Figure 2.

( ) Mount the meter through the large hole at the top of the panel and secure the meter to the panel by means of the clamp furnished. Be sure to align the meter square with the panel before tightening the clamp.



PICTORIAL 2

COIL WIRING

Note: The wiring of the oscillator and amplifier coils is somewhat difficult due to the large size wire used. The work may be performed from both the top of the chassis and through the large hole from the bottom. Care taken at this point will result in neatness and operating efficiency.

(✓) Connect a wire from SM3 (S) to + meter M1 (NS).

(✓) Connect a wire from SM6 (S) to - meter M2 (NS).

(✓) Connect a .001 μfd mica condenser from M1 (S) to M2 (S).

(✓) Connect a heavy tinned wire from CO1 on the oscillator tuning condenser (S) to XC1 on the oscillator coil (NS).

(✓) Connect a heavy tinned wire from XC1 (S) on the oscillator coil to the solder lug under the coil mounting screw (S).

(✓) Run a heavy tinned wire from SB4 on the band switch (S) through terminal XC4 on the oscillator coil to terminal CO2A on the tuning condenser. Solder XC4 and CO2A.

(✓) Connect a heavy tinned wire from SB2 (S) to XC3 (S).

(✓) Connect a heavy tinned wire from SB1 (S) to XC2 (S).

Note: The amplifier coils may be identified by the number of turns on each. The 10 meter coil 10C having the least turns, and the 80 meter coil 80C having the most. The coils 20C, 40C, and 80C have condensers connected across the terminals 1 and 2. See Figure 5 for mounting details.

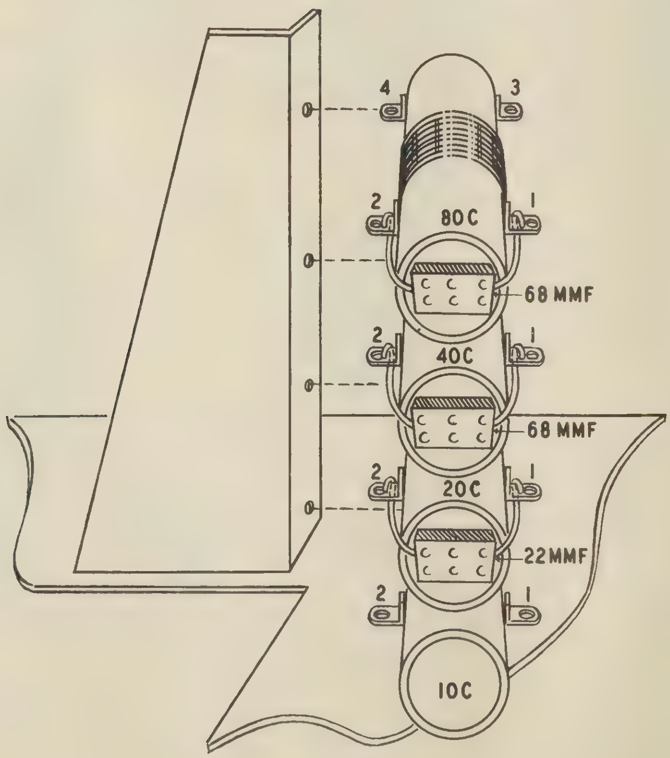


Fig. 5

(✓) Connect a 22 $\mu\mu$f 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 20C (NS).

(✓) Connect a 68 $\mu\mu$f 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 40C (NS).

(✓) Connect a 68 $\mu\mu$f 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 80C (NS).

(✓) Insert the 10 meter coil 10C in the lowest coil clamp. Connect a heavy tinned wire from 10C2 to SB11. Align the coil straight and parallel to the chassis; then solder the connections.

(✓) Connect a short heavy tinned wire from 10C4 (S) to SB6 (S).

(✓) Insert the 20 meter coil 20C in the next higher coil clamp.

(✓) Connect a short heavy tinned wire from 20C2 to SB12. Observe the same precautions as with the 10 meter coil and solder the connections.

(✓) Connect a short heavy tinned wire from 20C4 (S) to SB7 (S).

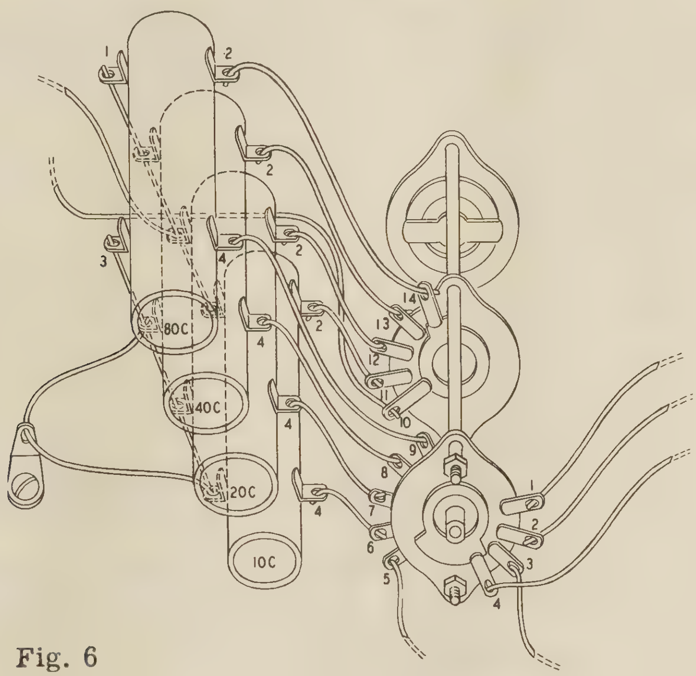


Fig. 6

(✓) Insert the 40 meter coil 40C in the next coil clamp.

(✓) Connect a short heavy tinned wire from 40C2 to SB13. Align the coil and solder the connections.

(✓) Connect a short heavy tinned wire from 40C4 (S) to SB8 (S).

(✓) Insert the 80 meter coil 80C in the top coil clamp.

(✓) Connect a short heavy tinned wire from 80C2 to SB14. Align and solder.

(✓) Connect a short heavy tinned wire from 80C4 (S) to SB9 (S).

(✓) Run a heavy tinned wire through the #1 terminals of all the coil. See Pictorial 2 and Figure 6.

( ) Solder connections 80C1 and 40C1.

( ) Connect one end of a heavy tinned wire to SB10 (S). Run this wire around coil 10C to CA2B on the tuning condenser (S). See Figure 6.

( ) Connect the end of the 100 $\mu\mu f$ condenser coming through the chassis to CA2A (S).

( ) Run a heavy tinned wire from CA1 on the amplifier tuning condenser to 20C1. Solder CA1 and 20C1.

( ) Run a heavy tinned wire through all the #3 terminals on the coils. Solder all connections but 10C3.

( ) Run a heavy tinned wire from 10C1 through the solder lug adjacent to the tube socket to 10C3. Solder all connections.

( ) On the bottom side of the chassis run the 6 1/2" length of bus between TB2 (S) and TC1 (S).

( ) Connect a heavy tinned wire to SB3 (S). Run this wire clear of terminal SB4 to the bus wire just installed. Make a firm connection to this bus and solder.

( ) Run a heavy tinned wire from SB5 down through the large hole in the chassis to the center terminal of the coax jack H. Arrange wire to clear all components and solder the connections. See Pictorial 1.

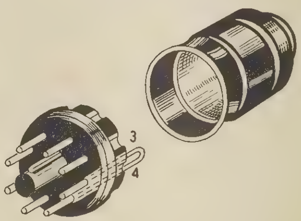
( ) Insert the AC line cord through the grommet F in the rear of the chassis. Tie a knot in the cord about 3" from the end.

( ) Connect one end of the cord to TA1 (S).

( ) Connect the other end to TA3 (S).

( ) On the male octal plug furnished, connect a jumper from pin 3 to pin 4 (S). See Figure 7.

Fig. 7



( ) Install the two round knobs on the tuning condensers. Align the pointers in such a manner that the pointer reads 100 when the condenser is fully meshed (maximum capacity).

( ) Install the pointer knobs on the band and meter switch. Tighten the set screw on the flat part of the switch shaft.

This completes the wiring of your Heathkit Model AT-1.

TRANSMITTER

TESTING THE TRANSMITTER

CAUTION: VOLTAGES DANGEROUS TO LIFE ARE PRESENT ON THIS TRANSMITTER. USE EXTREME CARE WHEN TRANSMITTER IS OUT OF CASE.

Before testing the transmitter, recheck all wiring. Damage to components may result due to errors in wiring.

( ) Insert an 80 meter crystal in the crystal socket.

( ) Plug a key into the key jack.

( ) Turn the STANDBY switch off and the OFF-ON switch on. Allow about two minutes for warmup.

( ) Turn the band switch to the 80M position and the meter switch to GRID position.

( ) Turn the STANDBY switch to PLATE-ON position and depress the key momentarily. The meter should indicate a low value of current. Release key.

( ) Turn the meter switch to the PLATE position and again depress the key. The meter should read a high value of current. Quickly tune the control marked OUTPUT. The meter should show a pronounced dip. Release key.

( ) Turn the band switch to the 40M position and the meter switch to the GRID position.

( ) Depress the key and tune the DRIVER control for maximum indication on the meter. Release key.

( ) Turn meter switch to the PLATE position and depress key. Tune the OUTPUT control for a pronounced dip. Release key.

( ) Repeat the last two steps on the 20 and 10 meter bands. If the results obtained are similar to those described above, the transmitter is operating correctly and may be installed in the cabinet. If not, refer to the section on trouble-shooting in the back part of this manual.

( ) Install the rubber feet on the cabinet. See Figure 8.

( ) Slide the transmitter into the cabinet being careful not to damage any of the components.

( ) Attach the transmitter to the cabinet by means of the two sheet metal screws in the rear and the eight sheet metal screws in the panel.

This completes the transmitter.

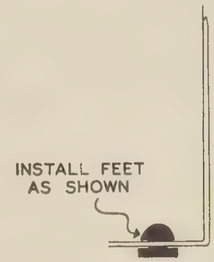


Fig. 8

COUPLING THE TRANSMITTER TO THE ANTENNA

Almost any piece of wire may be made to radiate when a source of RF power is connected to it. However, this does not mean it will radiate well and if an antenna is constructed based on this supposition, it is quite likely you will not get out of your backyard.

The results obtained with any transmitter are more dependent upon the antenna and the coupling system than upon the power input to the transmitter. Consequently, the effort applied to the design and installation of an efficient antenna system and the care taken in matching this system to the transmitter will be well worth the time and trouble taken.

It is not within the scope of this manual to go into a complete description of all types of antennas and coupling systems. Therefore, we will describe only a few basic types of antennas and coupling systems. For more detailed descriptions of antenna systems, the reader is referred to the handbooks published by amateur radio organizations.

END FED-HERTZ AND MARCONI

This consists merely of a single wire from 1/4 wave length long to any even multiple thereof. One end of the wire is coupled to the transmitter and the other end supported as free in space as possible. If this antenna is operated against ground, it is known as a MARCONI antenna. Its greatest disadvantage is due to the necessity of bringing part of the radiating element into the radio room where its proximity to nearby objects increases losses. Its greatest advantage is its simplicity and compact size where space is at a premium. See Figures 9 and 10.

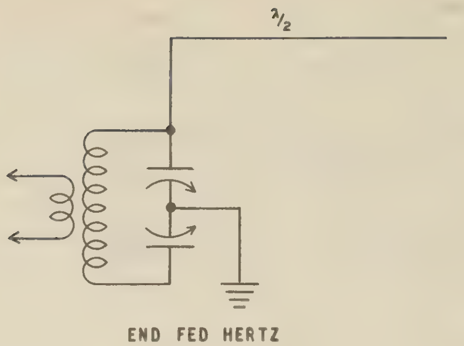


Fig. 9

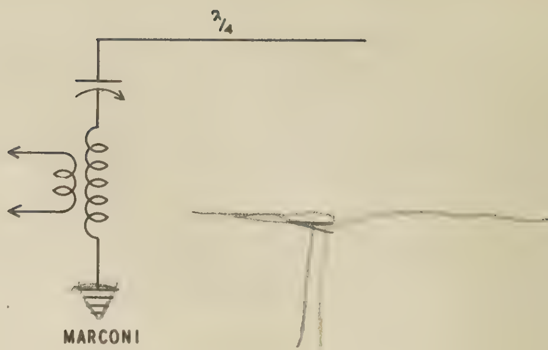


Fig. 10

In Figure 9 the coil and condenser combination should be capable of tuning to the transmitter output frequency. In Figure 10 the condenser should have a large capacity and the coil tapped to allow for any length of antenna.

END FED-ZEPP, DIPOLE, AND FOLDED DIPOLE ANTENNAS

In the average station, it will be found expedient to have the radiating portion of the antenna some distance from the transmitter. This statement assumes that the amateur will have his antenna up high and clear of nearby objects, whereas, the actual transmitter may be in the basement or any other room in the house. In this case, some form of transmission line must be used to efficiently connect the transmitter to the antenna.

There are two basic types of transmission lines; the untuned, non-resonant, or "flat" line, and the tuned, resonant line. The untuned line may be made any length within reason providing it meets all requirements of a non-resonant line. These requirements are quite critical. The untuned line must be physically symetrical throughout its length and must be terminated in its characteristic impedance. In general, it is a one band antenna as the terminating impedance of the antenna will not remain the same for operation on other bands. The untuned line has a standing wave ratio (SWR) of 1 to 1. More will be said about standing waves later.

The resonant or tuned transmission line is the type more generally used when it is desired to operate an antenna on several harmonically related bands. In this type of transmission line, standing waves are usually always present to some degree. They should be kept to a minimum.

STANDING WAVES: When energy is applied to one end of a transmission line, it flows out along the line from the source to the terminating point. In this case, the antenna. If the impedance of the terminating point exactly matches the surge impedance of the line, the energy is absorbed as fast as it arrives at that point. If the terminating point does not match the impedance of the line, some of the energy is reflected back along the line. The ratio of energy going out along the line to the amount reflected back along the line represents the standing wave ratio (SWR).

This, in turn, is equal to the ratio of mismatch between the line and its terminating point.

TRANSMISSION LINE SURGE IMPEDANCE:

$$Z_S = 276 \; LOG_{10} \frac{2S}{D}$$

S being the center to center spacing and D the diameter of the conductors measured in the same units.

This formula is for two-wire transmission lines. If coax cable is used for transmission line, the impedance is governed by the type used. This impedance being fixed in the manufacturing process. The impedance of an unknown coax line may be calculated from the following formula.

COAX IMPEDANCE:

$$Z_0 = 138 \text{ LOG}_{10} \frac{D_1}{D}$$

D_1 being the inside diameter of the outer conductor. D the outside diameter of the inter-conductor measured in the same units.

The antenna systems mentioned at the beginning of this section all use some form of transmission line, either coax or two-wire line can be used on any of them but may not be as well suited to one as to the other.

The Zepp antenna, which is an End Fed type capable of multi-band operation, is usually used with the two-wire tuned line. It has been the "hams" old standby for many years and is ideally suited where one end of the antenna is in the vicinity of the transmitter. It is tuned either in series or parallel depending upon the electrical length of the transmission line. The Zepp antenna may be coupled to the transmitter as shown in Figure 11.

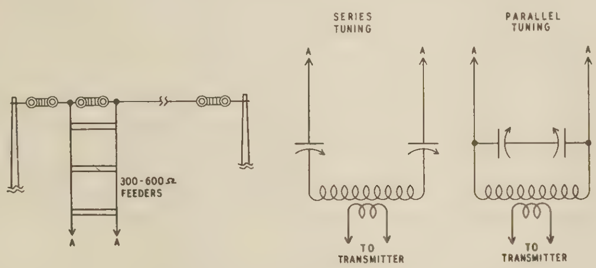


Fig. 11

The dipole, sometimes incorrectly called a Center Fed Zepp, consists of two quarter wave elements with the transmission line connected at the electrical center. The characteristic impedance of this type antenna is approximately 72 ohms and, as such may be used with 72 ohm coax to form a non-resonant line providing the electrical length of the antenna proper is exactly matched to the frequency operated.

As previously stated, this form of transmission line tends to limit the antenna to one-band operation. Consequently, the center fed antenna is usually fed with a two-wire resonant system and is tuned in the same manner as shown in Figure 11 for the end fed Zepp antenna.

The folded dipole antenna is ideally suited to flat line operation and although this again presents the single band characteristic, it probably represents the easiest method for the beginning amateur to get on the air. The characteristic impedance of the folded dipole is approximately 300 ohms, which just happens to be the surge impedance of the "twin-lead" used in TV work. Thus, by using "twin-lead" for the flat top part of the antenna and more of the same for the transmission line, we have our antenna ready to radiate. The method of doing this is illustrated in Figure 12.

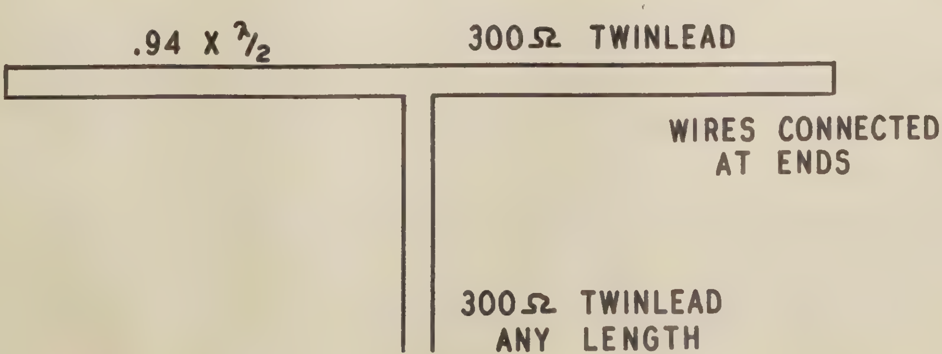


Fig. 12

The two wires of the "twin-lead" are shorted at the ends, and one of the wires is opened at the center to form the flat top. Another piece of "twin-lead" is connected to the open center wires to form the transmission line. It is recommended that transmitting type "twin-lead" be used. Antennas of this type are available commercially.

ANTENNA FORMULA

One Wave Length in Space = $\dfrac{300{,}000}{F_{kc}}$ Meters

Center Fed Dipole One Half Wave Long - Length in feet = $\dfrac{468}{F_{mc}}$

Folded Dipole One Half Wave Long - Length in feet = $\dfrac{462}{F_{mc}}$

Zepp Antenna One Half Wave Long - Length in feet = $\dfrac{492}{F_{mc}}$

ANTENNA COUPLER

The antenna coupler must meet one main requirement. It must match the transmission line to the output of the transmitter. It must also serve as a method of variable coupling between the antenna and the RF amplifier, if this has not been taken care of in the transmitter. It helps to eliminate TVI by the suppression of harmonics.

Basically, the antenna coupler is an impedance transformer, transforming the relatively high impedance output of the transmitter to the low impedance of the transmission line. The additional tuned circuit it incorporates tends to suppress harmonics present in the transmitter output. It may be placed some distance from the transmitter for convenience of connecting to the transmission line, providing coaxial cable is used to couple it to the transmitter. The AT-1 is equipped for coaxial coupling to the antenna coupler. See Figure 13 for details.

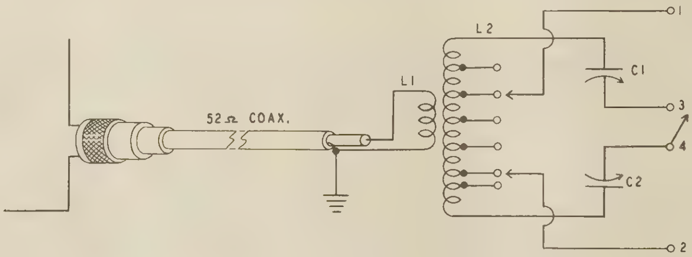


Fig. 13

The coil L1 should match the impedance of the coax cable as closely as possible at the frequency operated and the spacing between it and L2 should be adjustable to control the antenna loading.

The circuit consisting of L2, C1, and C2 must be capable of tuning to the transmitter frequency. If it is desired to series tune the antenna, the shorting bar between 3 and 4 is opened and the transmission line connected at these points. For parallel tuning, 3 is shorted to 4 and the transmission line connected to 1 and 2. Taps are provided on the coil L2 to facilitate matching the transmission line.

NOTE: For more complete information about antennas and coupling systems, refer to the amateur handbook.

AT-1 OPERATION ADJUSTMENTS

The AT-1 transmitter may be operated on the amateur bands of 80, 40, 20, 15, 11, and 10 meters using crystal or VFO control. Before attempting operation in any particular band, the operator should ascertain the frequency range of the desired band and the type of emission permissible in any portion of that band. After the desired frequency of operation has been arrived at, the crystal frequency necessary may be found by dividing the desired frequency by the harmonic relation to the crystal fundamental.

It is possible to operate the 10 meter band from an 80 meter crystal operating on its 8th harmonic but it is advisable to use 40 meter crystals for operation in the bands from 20 to 10 meters.

A VFO may be used to control the transmitter by plugging the output of the VFO into the crystal socket. If a VFO is used, care should be taken to ascertain that the VFO output is within the band, particularly on the higher frequencies where the error will be multiplied.

80 METER OPERATION

NOTE: All adjustments should be made quickly as the tubes draw excessive current when their associated circuits are not in resonance.

It is assumed that the proper antenna and coupler is attached to the transmitter in the following paragraphs and that a key is plugged in.

Plug in a crystal with a frequency between 3,500 and 4,000 kc. Turn on power switch and allow transmitter to warm up for a short time. Leave STANDBY switch in STANDBY position. Turn the meter switch to the PLATE position. Turn on STANDBY switch, depress key and quickly tune OUTPUT control for a dip. It is not necessary to adjust the DRIVER control on this band.

While holding key depressed, tune antenna coupler for a rise in plate current. As the antenna is tuned for increased current, continuously adjust OUTPUT control for resonance as indicated by a dip in current. A point should be reached where the meter will still show a dip when tuned through resonance, but at a considerably increased current.

The final current reading with the antenna and transmitter both tuned to resonance should be about 60 to 80 milliamperes. If it is much lower than this, the antenna coupling should be increased. If a point is reached where it is no longer possible to dip the plate current, the antenna is over-coupled and the coupling should be reduced.

40 METER OPERATION

Plug in a crystal in the frequency range between 3,500 and 3,650 kc and turn meter switch to GRID position. Turn STANDBY switch to on, depress key and quickly tune DRIVER control for maximum meter reading. Release key. Turn meter switch to PLATE position, depress key and tune for dip. Tune antenna as outlined under 80 meter operation.

20, 15, 11 AND 10 METER OPERATION

The method of tuning for these bands is exactly the same method as for the 40 meter band, except for the choice of crystal frequencies. The 15 meter and 11 meter bands are operated on the 10 meter position of the band switch. Below is a chart of crystal frequencies necessary for operation in any of the amateur bands.

WARNING: The frequencies listed cover the entire band limits. It is not advisable to operate near the band edge. When operating in the 15 meter band with a crystal frequency near 5250 kc, it is possible to tune to the 6th harmonic. As the 6th harmonic of that crystal is outside of any of the amateur bands it should be avoided. In any case, where two dips are noted when tuning the OUTPUT control, the one giving the most pronounced dip is the correct tuning.

80 METERS	40 METERS	20 METERS
$\frac{3500 \text{ to } 4000 \text{ kc}}{\text{Crystal}}$	$\frac{7000 \text{ to } 7300 \text{ kc}}{\text{Crystal}}$	$\frac{14000 \text{ to } 14350}{\text{Crystal}}$
3500 to 4000 kc	3500 to 3650 kc	3500 to 3587.5 kc 7000 to 7175 kc

15 METERS	11 METERS	10 METERS
$\frac{21000 \text{ to } 21450 \text{ kc}}{\text{Crystal}}$	$\frac{26960 \text{ to } 27230 \text{ kc}}{\text{Crystal}}$	$\frac{28000 \text{ to } 29700 \text{ kc}}{\text{Crystal}}$
5250 to 5362.5 kc	6740 to 6807.5 kc	3500 to 3712.5 kc 7000 to 7425 kc 14000 to 14850 kc

Crystals operating between any of the figures listed above can be used for operating the AT-1 in the band they are listed under.

RADIO TELEPHONE OPERATION

NOTE: Phone operation is limited to certain parts of the amateur bands only. It is also restricted to certain grades of amateur licenses. This must be taken into consideration before operating the AT-1 as a phone transmitter.

Modulation of a transmitter involves several factors not present in CW operation. For example, the load presented by the radio frequency amplifier must match the output impedance of the modulator. The modulator must have an impedance matching device, such as a transformer with the proper ratio to match the load resistance of the modulator tubes to the radio frequency load. The modulator must be capable of an audio output equal to 1/2 the power input to the radio frequency amplifier for 100% modulation. Some form of microphone and speech amplifier is necessary and the modulator for amateur use should reject audio frequencies above 3,000 cycles per second.

Frequencies above 3 kc are not necessary for the transmission of intelligent speech. Therefore, any frequencies above this figure not only waste usuable power but cause interference to other stations by increasing the band width of the transmitted signal.

MODULATOR DESIGN

The method of calculating the load impedance presented by the radio frequency amplifier when plate modulated is given by the formula:

$$Z_m = \frac{E_b \times 1000}{I_p}$$

where E_b is the amplifier plate voltage and I_p is the amplifier plate current in <u>milliamperes</u>. In the case of a screen grid tube, such as the 6L6 used in the AT-1, both plate <u>and screen</u> are modulated, so I_p used in the formula represents the total current for both plate and screen grid. EXAMPLE: AT-1 transmitter operating with 400 volts on the plate and 80 MA total plate and screen grid current:

$$Z_m = \frac{400 \times 1000}{80} = 5000\ \Omega \text{ Load Impedance}$$

Power input to the amplifier is expressed by the formula:

$$\text{Power In Watts} - E_b I_p$$

E_b is the amplifier plate voltage and I_p is the amplifier plate current in amperes.

As we require half the audio power output that we have RF power input, the audio requirements under the operating conditions stated above will be:

$$\text{Audio output in watts} - .5 \times 400 \times .080 \text{ or } 16 \text{ watts}$$

From the tube table it is found that push-pull 6L6's operating class AB_1 with 250 plate volts will give an output of 18 watts. The plate to plate load resistance of the tubes is found to be 5,000 ohms. Therefore, an output transformer having a 5,000 ohm primary and a ratio of total primary to secondary turns of 1 to 1 will match the modulator to the transmitter.

NOTE: This example only applies to one set of conditions, a change in the antenna loading will cause a change in RF amplifier plate current with a subsequent change in load impedance and wattage input. A different choice of modulator tubes would affect the output transformer necessary. However, from the formula given above, the modulator for any set of operating conditions may be calculated.

The reader is again referred to the amateur radio handbooks for more detailed information on the subject of phone operation.

MODULATION CONNECTIONS TO THE AT-1

In order to modulate the AT-1 transmitter, it is merely necessary to remove the jumper from pins 3 and 4 on the male octal plug, and connect the proper impedance output from the modulator transformer across these two pins. As the output of the modulator is AC, either terminal of the modulation transformer may be connected to either pin on the octal plug.

As the output impedance of the modulation transformer is more or less fixed, it is usually customary to adjust the transmitter by loading the antenna to a lesser or greater degree in order to present the proper RF load impedance to match the modulator.

VFO OPERATION

When using a VFO with the AT-1, it will be necessary to short out the cathode of the RF choke and resistor on the 6AG7. If a wire is connected from A5 to D6, an octal plug having a jumper between pins 6 and 7 may be inserted in socket D for VFO operation. If the VFO receives its power from the AT-1, its plug can be wired in the same manner.

IN CASE OF DIFFICULTY

The greatest single cause of trouble is due to wiring mistakes. First, check very carefully the transmitter wiring. Due to the large amount of bare wire used in this kit, there is a good chance that a short circuit will occur. All bare wire should be kept away from the chassis and other components.

The meter may be used to some degree in trouble shooting. In the GRID position, it indicates whether the oscillator is operating correctly and, in the PLATE position, it does the same for the amplifier stage. No deflection of the meter in either position usually indicates the trouble is in the power supply.

A voltage chart is often a good means of locating trouble. The chart below gives the voltages to be expected under normal operating conditions. All readings are DC, except where indicated. These voltages were measured with an 11 megohm input vacuum tube voltmeter. A normal variation of ±15% is to be expected. With regular voltmeters, reading may be somewhat lower.

SOCKET VOLTAGE CHART

TUBE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
5U4G	0	450	440	430AC	0	430AC	0	450
6AG7	0	6.3AC	0	-95	3.5	220	0	430
6L6	0	0	420	250	-45	0	6.3AC	0

The trouble shooting chart included at this point may also be used to good advantage in case difficulty occurs.

TROUBLE	SYMPTOMS	POSSIBLE CAUSE
Transmitter inoperative	Meter reads high current in PLATE position. No indication in GRID position.	Oscillator not oscillating due to: 1. Defective or dirty crystal. 2. Defective 6AG7 tube. 3. No voltage on oscillator plate or screen grid. (Pins 6 and 8 on voltage chart.) 4. Shorted or open circuit on oscillator coil or terminals SB1 through 4 on the band switch. 5. DRIVER control not tuned properly.
Transmitter inoperative	Meter reads in GRID position. Does not read in PLATE position.	Amplifier not drawing current due to: 1. Modulator plug not inserted in socket. 2. Modulator plug does not have jumper between terminals 3 and 4. 3. Defective 6L6 tube. 4. No voltage on plate and screen grids. (Pins 3 and 4 on the voltage chart.) 5. Cathode circuit to ground open. (Check key jack.) 6. Plate voltage supply open at meter switch. (Terminals 1 and 4 on meter switch.)
Transmitter inoperative	Meter reads in both GRID and PLATE positions. OUTPUT tuning will not dip meter current.	Amplifier will not resonate due to: 1. 100 $\mu\mu f$ 1,000 volt condenser circuit open between B3 and CO2A. 2. "Tank" circuit open between CA2B and SB10. 3. Amplifier coil connections shorted. 4. Switch positions SB10 through 14 open or shorted. 5. Antenna overcoupled.
Transmitter inoperative	Meter does not read in either position.	No voltages on tubes due to: 1. Open circuit at switches S1 or S2. 2. Defective 5U4G tube. 3. Short in high voltage circuit. 4. Open circuit at SM3 or 6 on the meter switch.

Transmitter will not load when connected to an antenna.	No increase in plate current with antenna connected.	1. Short or open connections on #4 amplifier coil terminals. 2. Shorted or open connections on terminals SB5 through 9 on the band switch. 3. Antenna coupler not tuned to band being operated. 4. Inefficient antenna.

TELEVISION INTERFERENCE (TVI)

There is no single method of combating television interference that will apply to all circumstances. Each individual installation may require a different technique. However, a few hints are included here covering the usual methods of eliminating TVI.

LOW-PASS FILTER

A low-pass filter inserted in the coaxial line between the transmitter and the antenna coupler is very effective. The low-pass filter will eliminate any harmonic radiation above its cutoff frequency, usually 40 to 50 mc. The figure below describes one method of making a low-pass filter.

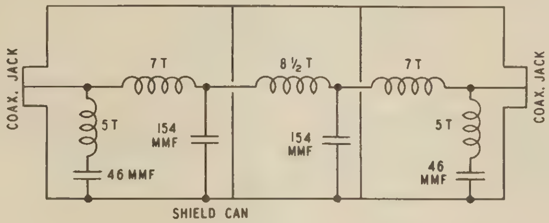


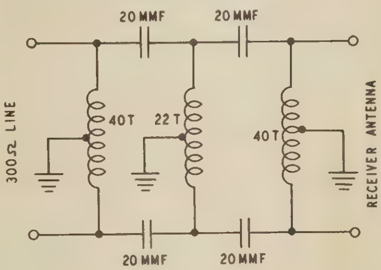
Fig. 14

Coils are wound of No. 12 or 14 wire 1/2" inside diameter, spacing 8 turns per inch.

HIGH-PASS FILTER

The high-pass filter is used where only one or two television sets are affected out of many. It must be inserted in the TV lead-in directly at the antenna terminals of the receiver. The figure below describes one method of making a high-pass filter.

Fig. 15



Coils are wound of No. 30 wire on a 1/8" diameter form.

AC LINE FILTER

It is sometimes possible that the transmitter is feeding energy from the antenna into the house wiring. This energy in turn is fed directly into the receiver through its line cord. The figure below shows a method of constructing an AC line filter for the receiver.

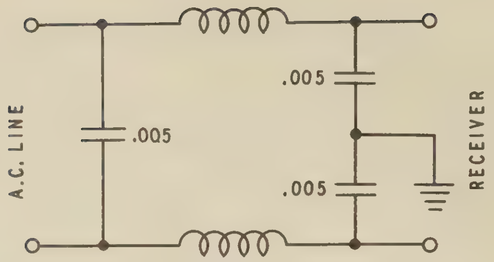


Fig. 16

The coils consist of a 2" length of close wound No. 18 wire on 1/2" diameter form.

There are numerous other methods which will help to eliminate TVI. In general, the transmitting antenna should be kept away from receiving antennas. All RF components should be shielded. Consequently, the AT-1 should be operated in the case at all times.

For further information on television and broadcast interference elimination, refer to the amateur handbooks.

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $5.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the proper operation of your instrument and therefore this factory repair service is available for a period of one year from the date of purchase.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted. Attach a tag to the instrument giving name, address and trouble experienced. Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

SPECIFICATIONS

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

WARRANTY

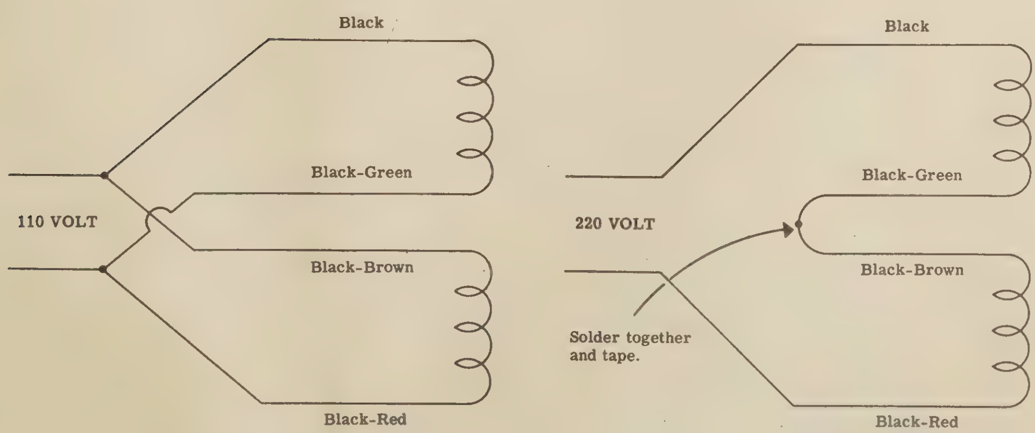
The Heath Company limits its warranty of parts supplied with any kit (except tubes, meters and rectifiers, where the original manufacturer's guarantee only applies) to a period of three (3) months from the date of purchase. Replacement will be made only when said part is returned postpaid, with prior permission and in the judgment of the Heath Company was defective at the time of sale. This warranty does not extend to any Heathkits which have been subjected to misuse, neglect, accident and improper installation or applications. Material supplied with a kit shall not be considered as defective, even though not in exact accordance with specifications, if it substantially fulfills performance requirements. This warranty is not transferable and applies only to the original purchaser. This warranty is in lieu of all other warranties and the Heath Company neither assumes nor authorizes any other person to assume for them any other liability in connection with the sale of Heathkits.

The assembler is urged to follow the instructions exactly as provided. The Heath Company assumes no responsibility for the operation of the completed instrument, nor liability for any damages or injuries sustained in the assembly or operation of the device.

HEATH COMPANY
Benton Harbor, Michigan

WIRING OF EXPORT TYPE
110/220 VOLT POWER
TRANSFORMERS

These transformers have a dual primary for use on either 110 Volts or 220 Volts. Wire as shown.



110 VOLT

220 VOLT

PARTS LIST

HEATHKIT AMATEUR TRANSMITTER

MODEL AT-1

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-3	1	100 Ω 1/2 watt
1-16	1	4.7 KΩ 1/2 watt
1-26	1	100 KΩ 1/2 watt
1-43A	1	51 Ω 1 watt 5%
1-17A	1	100 Ω 1 watt
1-11B	1	22 KΩ 2 watt
1-10B	4	47 KΩ 2 watt
Condensers		
20-29	1	15 μμf 500 volt mica
20-30	1	22 μμf 1 kv silver mica
20-31	2	68 μμf 1 kv silver mica
20-11	3	100 μμf 500 volt mica
20-32	1	100 μμf 1 kv mica
20-33	7	.001 μfd 500 volt mica
23-15	1	.5 μfd 400 volt paper
~~26-14~~ 21	2	50 μμf variable
25-22	4	8 μfd 350 volt electrolytic
Switches		
60-1	2	SPST slide switch
63-52	1	3 pole 3 position rotary
63-53	1	2 pole 3 position rotary
Transformers-Coils-Chokes		
54-21	1	Power transformer
46-7	1	Filter choke
45-4	2	1.1 MH RF choke
45-7	1	90 μh RF choke
40-32	1	Oscillator coil
40-33	1	80 M amplifier coil
40-34	1	40 M amplifier coil
40-35	1	20 M amplifier coil
40-36	1	10 M amplifier coil
Tubes-Meters		
407-21	1	10 MA meter
411-2	1	5U4G tube
411-8	1	6L6 tube
411-53	1	6AG7 tube
Sockets-Terminal Strips		
431-2	1	2 Lug terminal strip
431-3	2	3 Lug terminal strip
431-5	1	4 Lug terminal strip
434-38	1	Crystal socket
434-39	5	Octal tube socket
436-4	1	Phone jack
436-5	1	Coaxial jack
438-6	1	Octal plug
438-9	1	Coaxial plug

PART No.	PARTS Per Kit	DESCRIPTION
Hardware		
73-1	2	3/8" rubber grommet
206-2	4	Spring clip
250-8	10	#6 sheet metal screw
250-9	24	6-32 round head screw
~~250-7~~	~~4~~	~~6-32 x 3/16 screw~~
250-18	4	8-32 round head screw
250-34	5	4-40 round head screw
252-3	24	6-32 hex nut
252-4	4	8-32 hex nut
252-7	35	Control nut
252-15	5	4-40 hex nut
253-10	85	Control washer
254-1	25	#6 lockwasher
254-2	4	#8 lockwasher
254-4	24	Control lockwasher
259-1	3	#6 solder lug
250-22	2	Set screw
Miscellaneous		
89-1	1	Line cord
90-22	1	Cabinet
200-M49	1	Chassis
203-M45F58	1	Panel
204-M47	1	Coil bracket
261-1	4	Rubber feet
340-1	1	length #14 bare wire
340-3	1	length #16 bare wire
344-1	1	roll Hookup wire
346-1	1	length Spaghetti
462-M11	2	Pointer knob
462-15	2	Round skirt knobs 1 broken
595-64	1	Manual

HELPFUL KIT BUILDING INFORMATION

Before attempting actual kit construction read the construction manual through thoroughly to familiarize yourself with the general procedure. Note the relative location of pictorials and pictorial inserts in respect to the progress of the assembly procedure outlined.

This information is offered primarily for the convenience of novice kit builders and will be of definite assistance to those lacking thorough knowledge of good construction practices. Even the advanced electronics enthusiast may benefit by a brief review of this material before proceeding with kit construction. In the majority of cases, failure to observe basic instruction fundamentals is responsible for inability to obtain desired level of performance.

RECOMMENDED TOOLS

The successful construction of Heathkits does not require the use of specialized equipment and only basic tools are required. A good quality electric soldering iron is essential. The preferred size would be a 100 watt iron with a small tip. The use of long nose pliers and diagonal or side cutting pliers is recommended. A small screw driver will prove adequate and several additional assorted screw drivers will be helpful. Be sure to obtain a good supply of rosin core type radio solder. Never use separate fluxes, paste or acid solder in electronic work.

ASSEMBLY

In the actual mechanical assembly of components to the chassis and panel, it is important that the procedure shown in the manual be carefully followed. Make sure that tube sockets are properly mounted in respect to keyway or pin numbering location. The same applies to transformer mountings so that the correct transformer color coded wires will be available at the proper chassis opening.

Make it a standard practice to use lock washers under all 6-32 and 8-32 nuts. The only exception being in the use of solder lugs—the necessary locking feature is already incorporated in the design of the solder lugs. A control lock washer should always be used between the control and the chassis to prevent undesirable rotation in the panel. To improve instrument appearance and to prevent possible panel marring use a control flat nickel washer under each control nut.

When installing binding posts that require the use of fiber insulating washers, it is good practice to slip the shoulder washer over the binding post mounting stud before installing the mounting stud in the panel hole provided. Next, install a flat fiber washer and a solder lug under the mounting nut. Be sure that the shoulder washer is properly centered in the panel to prevent possible shorting of the binding post.

WIRING

When following wiring procedure make the leads as short and direct as possible. In filament wiring requiring the use of a twisted pair of wires allow sufficient slack in the wiring that will permit the twisted pair to be pushed against the chassis as closely as possible thereby affording relative isolation from adjacent parts and wiring.

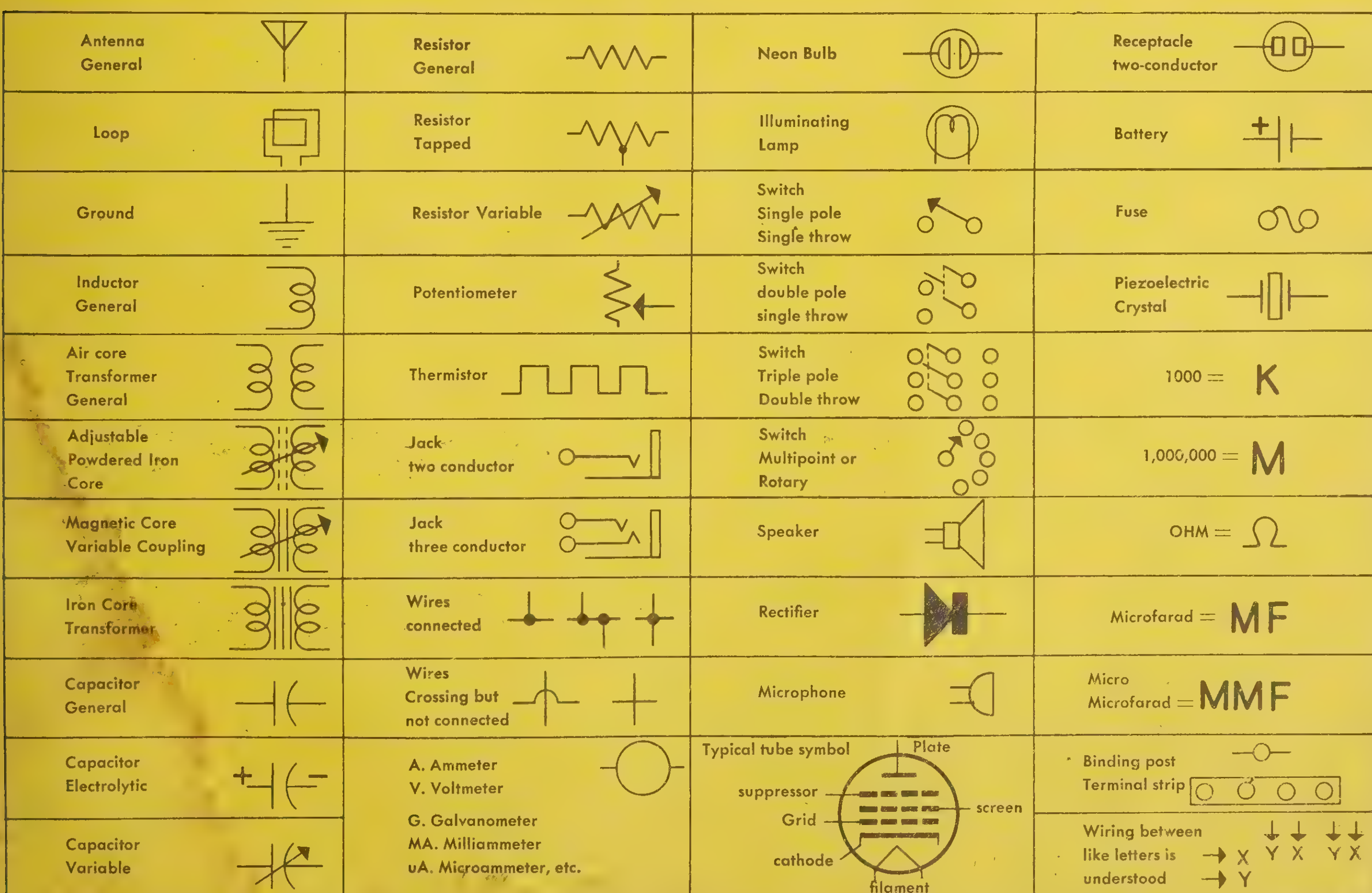
When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the wire. Excessive insulation removal may cause a short circuit condition in respect to nearby wiring or terminals. In some instances, transformer leads of solid copper will have a brown baked enamel coating. After the transformer leads have been trimmed to a suitable length, it is necessary to scrape the enamel coating in order to expose the bright copper wire before making a terminal or soldered connection.

In mounting parts such as resistors or condensers, trim off all excess lead lengths so that the parts may be installed in a direct point-to-point manner. When necessary use spaghetti or insulated sleeving over exposed wires that might short to nearby wiring.

It is urgently recommended that the wiring dress and parts layout as shown in the construction manual be faithfully followed. In every instance, the desirability of this arrangement was carefully determined through the construction of a series of laboratory models.

SOLDERING

Much of the performance of the kit instrument, particularly in respect to accuracy and stability, depends upon the degree of workmanship used in making soldered connections. Proper soldered connections are not at all difficult to make but it would be advisable to observe a few precautions. First of all before a connection is to be soldered, the connection itself should be clean and mechanically strong. Do not depend on solder alone to hold a connection together. The tip of the soldering iron should be bright, clean and free of excess solder. Use enough heat to thoroughly flow the solder smoothly into the joint. Avoid excessive use of solder and do not allow a flux flooding condition to occur which could conceivably cause a leakage path between adjacent terminals on switch assemblies and tube sockets. This is particularly important in instruments such as the VTVM, oscilloscope and generator kits. Excessive heat will also burn or damage the insulating material used in the manufacture of switch assemblies. Be sure to use only good quality rosin core radio type solder.



Courtesy of I. R. E.

HEATH COMPANY
BENTON HARBOR, MICHIGAN

THE WORLD'S *Finest* TEST EQUIPMENT IN KIT FORM

ASSEMBLING AND USING YOUR . . . . . Heathkit

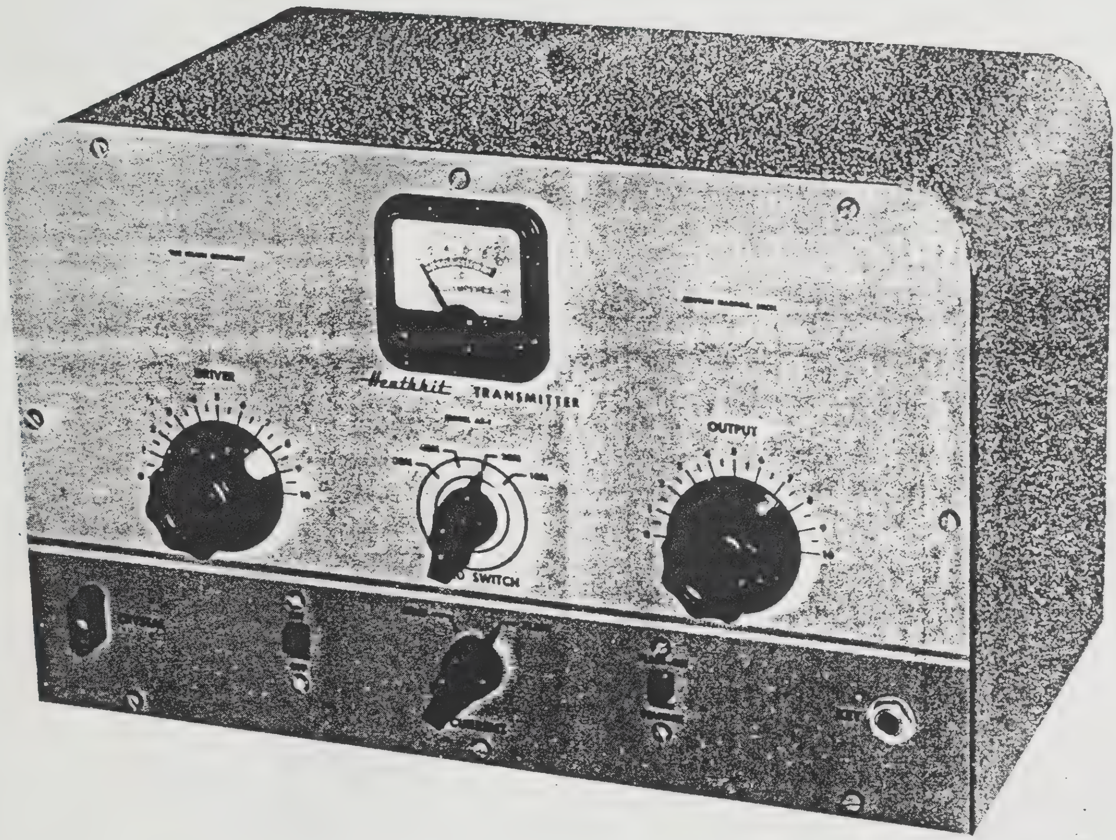
AMATEUR TRANSMITTER
MODEL AT-1

595-64

HEATH COMPANY
BENTON HARBOR, MICHIGAN

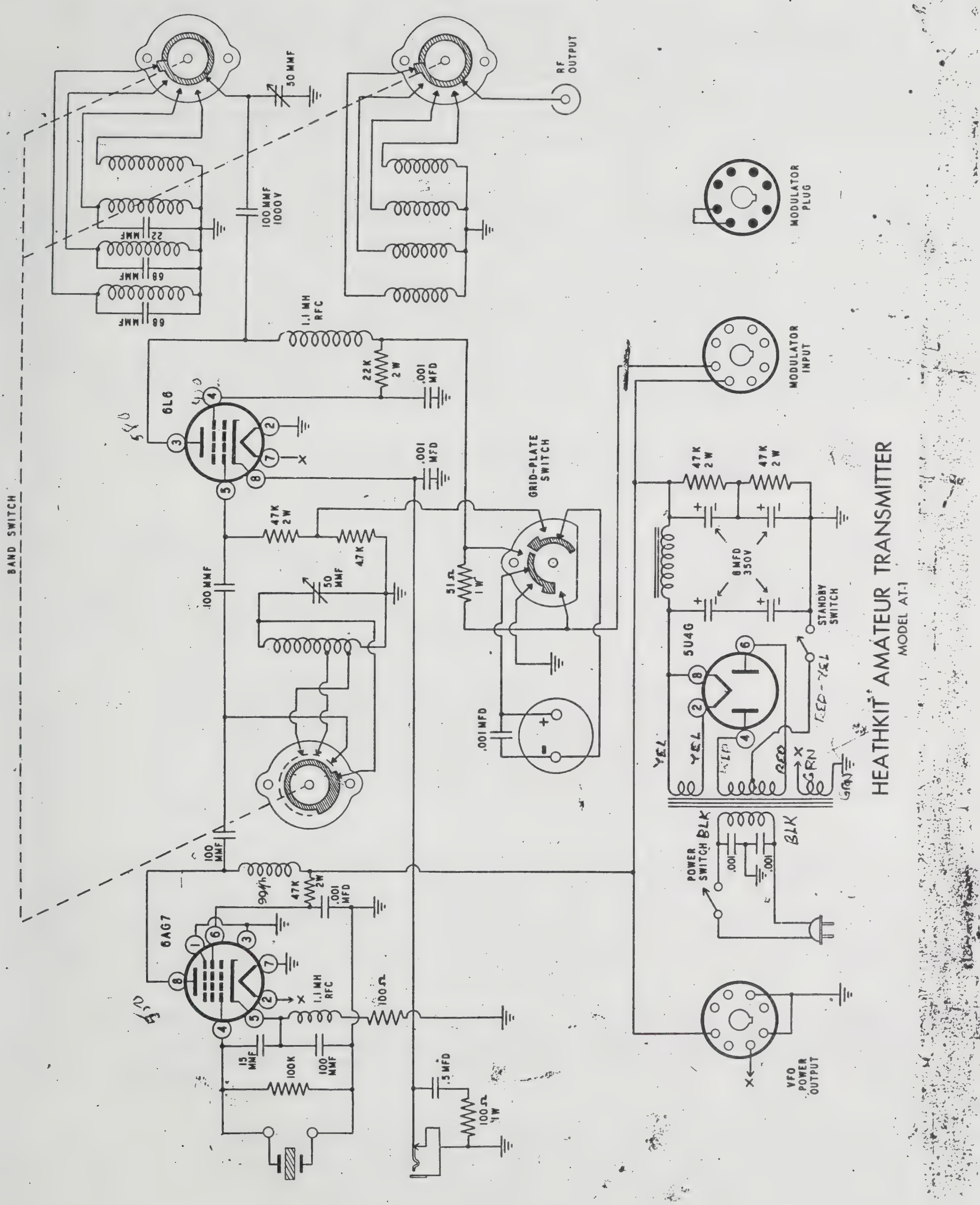
PRICE $1.00

ASSEMBLY AND OPERATION OF THE
HEATHKIT AMATEUR TRANSMITTER
MODEL AT-1



SPECIFICATIONS

RF Amplifier Power Input	25-30 Watts
Output Connection	52 Ohm Coaxial Cable
Oscillator Operation	Crystal, can be operated by a VFO
Amplifier Operation	CW, can be modulated for phone
Band Coverage	80, 40, 20, 15, 11, 10 Meters
Tube Complement	
5U4G	Rectifier
6AG7	Oscillator - Multiplier
6L6	Amplifier - Doubler
Power Requirements	105-125 50/60 Cycle, 100 Watts
Cabinet Size	8 1/8" high x 13 1/8" wide x 7" deep
Net Weight	13 lbs.


HEATHKIT AMATEUR TRANSMITTER
MODEL AT-1
BAND SWITCH
50 MMF
RF OUTPUT
100 MMF 1000V
22 MMF
68 MMF
68 MMF
1.1 MH RFC
22K 2W
.001 MFD
6L6
.001 MFD
GRID-PLATE SWITCH
47K 2W
47K
50 MMF
.100 MMF
51 Ω 1W
.001 MFD
MODULATOR PLUG
MODULATOR INPUT
47K 2W
47K 2W
8 MFD 350V
STANDBY SWITCH
5U4G
YEL
RED
GRN
BLK
RED-YEL
POWER SWITCH
.001
.001
100 MMF
6AG7
47K 2W
.001 MFD
1.1 MH RFC
100 Ω
15 MMF
100K
100 MMF
.5 MFD
100 Ω 1W
VFO POWER OUTPUT

INTRODUCTION

The Heathkit Model AT-1 Transmitter was designed to provide both the beginning and experienced amateur with a simply constructed yet versatile kit form transmitter at modest cost. Consideration was also given to the probable enlarging of the operator's station. Rather than become obsolete, the AT-1 can be operated with crystal or VFO control and used as an all-band exciter for a high power final. It has provision for modulation as a low power phone transmitter and can be used directly as such or used to drive a linear amplifier in a high power phone station. For the "old timer," it makes an excellent standby transmitter while the big "rig" is being overhauled.

The transmitter incorporates the maximum permissible shielding to minimize TVI from harmonics radiated directly by the transmitter. The amplifier stage operates as a doubler on the higher frequencies to eliminate the possibility of parasitic oscillations.

Although primarily designed for crystal operation, it will perform equally well when driven by a VFO and is equipped to supply the VFO with both plate and filament power from an octal socket on the rear of the transmitter chassis. The band switching knob on the panel switches both the oscillator and amplifier coils simultaneously. This not only increases the convenience of operation but also lessens the possibility of operation on the wrong crystal or VFO harmonic. A three position meter switch provides for measurement of the amplifier grid current, amplifier plate current, and has an "off" position for use when the transmitter is being keyed.

The transmitter incorporates tried and proven tube types and circuitry, careful layout, and quality components. It will give long and reliable service when properly constructed.

CIRCUIT DESCRIPTION

The power supply is conventional. A transformer steps up the AC line voltage to approximately 400 volts, which is then converted to direct current by the action of a 5U4G full-wave rectifier tube. Ripple component present in the output of the rectifier is removed by a "brute force" filter consisting of four electrolytic condensers and a filter choke. A switch in the AC line turns the transmitter ON and OFF. Another switch in the negative return shuts off the DC power when in the STANDBY position, leaving the filaments on.

The crystal oscillator consists of a 6AG7 tube operated in a tuned or untuned Colpitts circuit. The plate circuit of the oscillator is untuned when the transmitter is operated on the 80 meter band. This prevents coupling between oscillator and amplifier coils when both are at the same frequency. On all other bands the oscillator is operated as a tuned plate amplifier or doubler stage. One set of contacts on the band switch inserts the proper oscillator coil for each band. Grid bias for the 6AG7 is obtained mainly from a grid leak resistor and partially from resistance in the cathode circuit.

The output stage consists of a 6L6 amplifier-doubler which may be operated up to approximately 30 watts input on CW or Phone. Four coils each having preadjusted antenna coupling loops are connected in turn to the 6L6 plate circuit by the action of the band switch. These coils cover the frequency range from 3.5 to 30 mc. Bias for this stage is derived from the grid current flowing through the grid resistor and is only present when the stage is being excited by the oscillator. The Grid-plate meter has its full scale sensitivity automatically changed from 10 to 100 milliamperes when switched from the grid to plate position.

Two octal sockets on the rear of the chassis provide connections for audio input and VFO power output. A coaxial jack, when used with 52 ohm coax cable, provides a shielded RF output to the antenna coupler. A .5 μfd condenser and a 100 Ω resistor across the key jack provide an effective key click filter.

NOTES ON ASSEMBLY AND WIRING

The Heathkit Model AT-1 Amateur Transmitter, when constructed in accordance with the instructions in this manual, is a high quality reliable means of communication capable of years of trouble-free service. We therefore urge you to take the necessary time to assemble and wire the kit carefully. Do not hurry the work and you will be rewarded with the pride that comes from DX contacts with a self-constructed transmitter.

This manual is supplied to assist you in every way to complete the transmitter with the least possible chance for error. We suggest that you take a few minutes now and read the entire manual through before any work is started. This will enable you to proceed with the work much faster when construction is started. The large fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the completion of the kit. These diagrams are repeated in smaller form within the manual. We suggest that you retain the manual in your files for future reference, both in the use of the transmitter and for its maintenance.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you to identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

Read the note on soldering on the inside of the back cover. Crimp all leads tightly to the terminal before soldering. Be sure both the lead and the terminal are free of wax, corrosion, or other foreign substances. Use only the best rosin core solder, preferably a type containing the new activated fluxes, such as Kester "Resin-Five," Ersin "Multicore," or similar types.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

Resistors and condensers generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on condensers are generally even greater. Limits of +100% and -50% are common for electrolytic condensers. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished transmitter.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are carefully checked before they are approved, and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you may find that a 2.2 megohm resistor has been supplied in place of a 2 megohm as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion in checking the contents of your kit.

We strongly urge that you follow the wiring and parts layout shown in this manual. The position of wires and parts is extremely critical in a high frequency transmitter, and changes may seriously affect the characteristics of the circuit.

STEP-BY-STEP ASSEMBLY INSTRUCTIONS

The following instructions are presented in a simple, logical, step-by-step sequence to enable you to complete your kit with the least possible confusion.

Be sure to read each step all the way through before starting. When a step is completed, check it off in the space provided. This makes it easy to resume construction after your work has been interrupted.

NOTE: We suggest that you do the following before any work is started:

1. Select from the large fold-in pictorials included with the manual the diagram showing the phase of construction you are engaged in at the time. Attach this diagram to the wall above your work space.
2. After identifying the parts from the parts list, lay them out in a large shallow box so that they are readily accessible. This will save considerable time in construction.
3. Read thoroughly the assembly and wiring instructions on the inside rear cover of the manual and refer to the general information on both inside covers of the manual to identify the parts.
4. In assembling the kit, use lockwashers under all nuts unless a solder lug is used. Tube sockets are mounted with the metal flange inside the chassis. All screws have their heads on top or outside of the chassis. This construction may be noted by referring to Figure 1. Unless otherwise stated, 6-32 screws, lockwashers and nuts are used in mounting of parts.

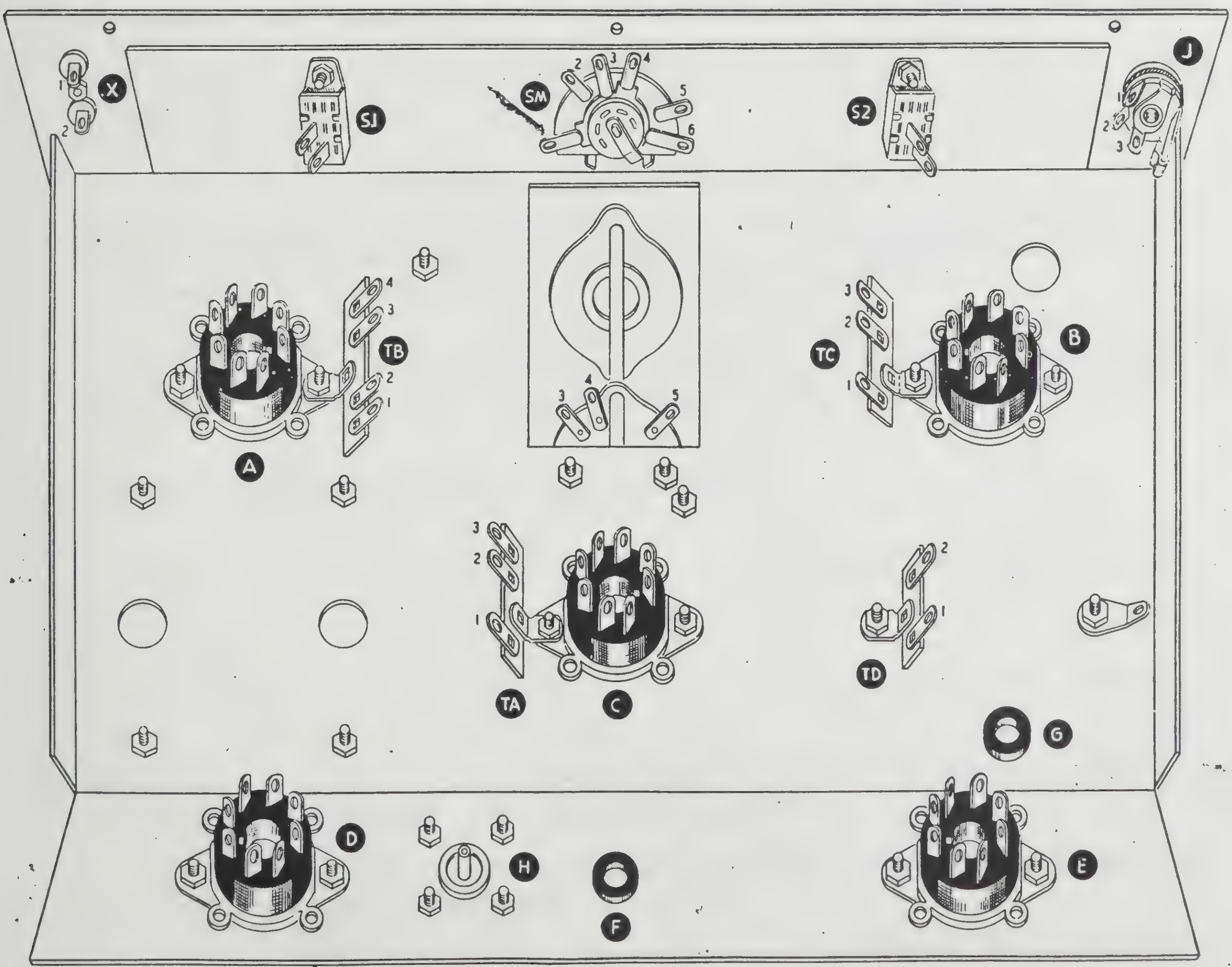


Fig. 1

CHASSIS ASSEMBLY

( ) Mount an octal socket in hole A with the keyway toward the center of the chassis. At the same time mount a four-lug terminal strip under the chassis, using the mounting screw nearest the center of the chassis. As previously stated, 6-32 screws, lockwashers and nuts are used in mounting all parts unless otherwise specified.

( ) Mount an octal socket in hole B with the keyway toward the center of the chassis. At the same time, mount a three-lug terminal strip under the chassis and a solder lug on top of the chassis, using the mounting screw nearest the center of the chassis as shown in Figures 1 and 2.

( ) Mount an octal socket in hole C with the keyway toward the right side of the chassis when viewed from the rear and a three-lug terminal strip mounted on the left hand mounting screw. Refer to Figure 1.

( ) Mount two octal sockets in holes D and E with their keyways as shown in Figure 1.

( ) Insert 3/8" rubber grommets in holes F and G.

( ) Mount the coaxial output jack in hole H using 4-40 screws and nuts.

( ) Mount the filter choke on top of the chassis with the leads over the grommet G using the two mounting holes at the right rear of the chassis. Place a solder lug under the nut nearest the edge of the chassis and a two-lug terminal strip under the other nut. See Figure 1.

( ) Mount the power transformer on top and at the left rear of the chassis, using 8-32 screws, nuts and lockwashers. Orient the transformer so that the red leads emerge nearest the center of the chassis.

ASSEMBLY OF CHASSIS TO PANEL

( ) Mount the two slide switches S-1 and S-2 with their terminal lugs in the position shown in Figure 1. The mounting screws for these switches go through both the panel and the chassis and secure the chassis to the panel. Do not tighten the screws yet.

( ) Mount the meter switch SM through the 3/8" hole in the center of the panel and chassis, using a 3/8" lockwasher behind the chassis and a 3/8" flatwasher and nut in front of the panel. Refer to Figure 1 for switch position and to Figure 3 for method of mounting controls.

( ) Align panel square with chassis and tighten screws.

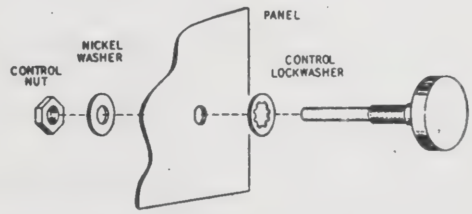


Fig. 3

HOW TO MOUNT CONTROLS & SWITCHES

( ) Mount the phone jack in the hole provided at the right bottom of the panel, using a lockwasher, flatwasher and nut. Position as shown in Figure 1.

( ) Mount the crystal holder so that the terminals protrude through the back of the panel as shown in Figure 1, using a 4-40 screw and nut.

Note: The tuning condensers and coil assembly will be mounted after the bottom of the chassis has been wired.

WIRING OF THE AT-1 TRANSMITTER

NOTE: Before beginning the wiring, refer again to the notes on wiring and soldering on the inside rear cover of the manual. We cannot stress too strongly the importance of careful wiring and soldering when applied to radio frequency circuits. In building this transmitter, you will use a considerable amount of heavy tinned wire. Both from the standpoint of neatness and efficiency, the leads should be kept short and straight. Sharp bends are to be avoided when possible and RF leads in the grid and plate circuits should be isolated as far as possible from other circuits and from each other. Soldering should be done with a great deal of care so that fluxes will not run over onto adjacent insulation; thus causing leakage and a possible loss of power.

Components are given code designations so that identification of parts on both the diagrams and on the written matter is easily defined. The tube sockets are numbered A to E inclusive and correspond to the mounting holes referred to previously under assembly instructions. It is recommended that the tube sockets be marked in pencil on the bottom of the chassis, A to E.

Switches are designated as S-1, S-B, etc. Other parts are referred to in a similar manner which will be readily apparent as the work progresses. Octal sockets are numbered in a clockwise direction, starting from the left of the keyway when viewed from the bottom. The grounding lugs attached to the sockets are numbered in the same way. See Figure 4.

Thus a connection to B5 means terminal 5 counted in a clockwise direction from the keyway on socket B. Similarly, AG-3 is the number 3 ground lug measured in the same manner on socket A.

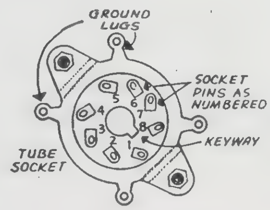


Fig. 4

Leads on resistors, condensers and transformers are generally much longer than they need to be to make the indicated connections. In these cases, the excess leads should be cut off before the part is added to the chassis. Not only does this make the wiring much neater, but in radio frequency work the excess length of the lead may actually create tuned parasitic circuits at undesired frequencies.

Wire is to be insulated unless otherwise specified. Insulated sleeving is to be used on bare wires when called for.

WIRING OF POWER SUPPLY

(S) means solder. (NS) means do not solder yet.

NOTE: Refer to the schematic and to Pictorial 1 for the following wiring.

( ) Connect a .001 μfd condenser from TA1 (NS) (use sleeving) to CG1 (S). See Pictorial 1.

( ) Connect a .001 μfd condenser from TA2 (NS) (use sleeving) to CG4 (S).

( ) Twist the red leads from the power transformer together and connect one red lead to C4 (S).

( ) Connect the other red lead from the transformer to C6 (S).

( ) Connect the red-yellow lead from the transformer to C7 (NS).

( ) Twist the yellow leads from the transformer together and connect one yellow lead to C2 (S).

( ) Connect the other yellow lead from the transformer to C8 (NS).

( ) Twist the green leads from the transformer together and connect one green lead to D2 (NS).

( ) Connect the other green lead from the transformer to DG4 (NS).

( ) Twist the black leads from the transformer together and connect one black lead to TA1 (NS).

( ) Connect the other black lead to TA2 (NS).

( ) Twist together two pieces of hookup wire about 7" long. Strip the insulation from one pair of ends and connect to the terminals of S1 (S).

( ) Run the twisted pair of leads close to the chassis to terminals TA2 and TA3. Cut wire to proper length and connect either one to TA2 (S) and the other to TA3 (NS).

( ) Connect a lead from A2 (NS) to D2 (S).

( ) Run a piece of light bare wire from D1 (S) through D7 (S) to DG4 (S).

( ) Connect a wire from C7 (S) to either terminal on switch S2 (S).

( ) Connect a wire from the other switch terminal (S) to J2 (NS) on the phone jack.

( ) Connect a short bare wire from J2 (S) to J3 (S).

( ) Connect a wire from A2 (S) to B7 (S).

( ) Twist the leads from the filter choke together and pass them through the grommet G. Run these leads close to the back edge of the chassis over to the socket C.

( ) Connect one lead of the choke to C8 (NS).

( ) Connect the other lead to C3 (NS).

Note: In wiring the following condensers, cut the leads to a length that will allow the condensers to fit snugly between their connection points. See Pictorial 1.

( ) Connect the positive lead of an 8 μfd 350 volt condenser to C8 (S). The positive lead will have the word POSITIVE or PLUS markings on that end of the condenser case. Connect the other lead of this condenser to TD2 (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to TD2 (S).

( ) Connect the other lead of this condenser to the solder lug near the chassis edge (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to C3 (NS).

( ) Connect the other lead of this condenser to TD1 (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to TD1 (NS).

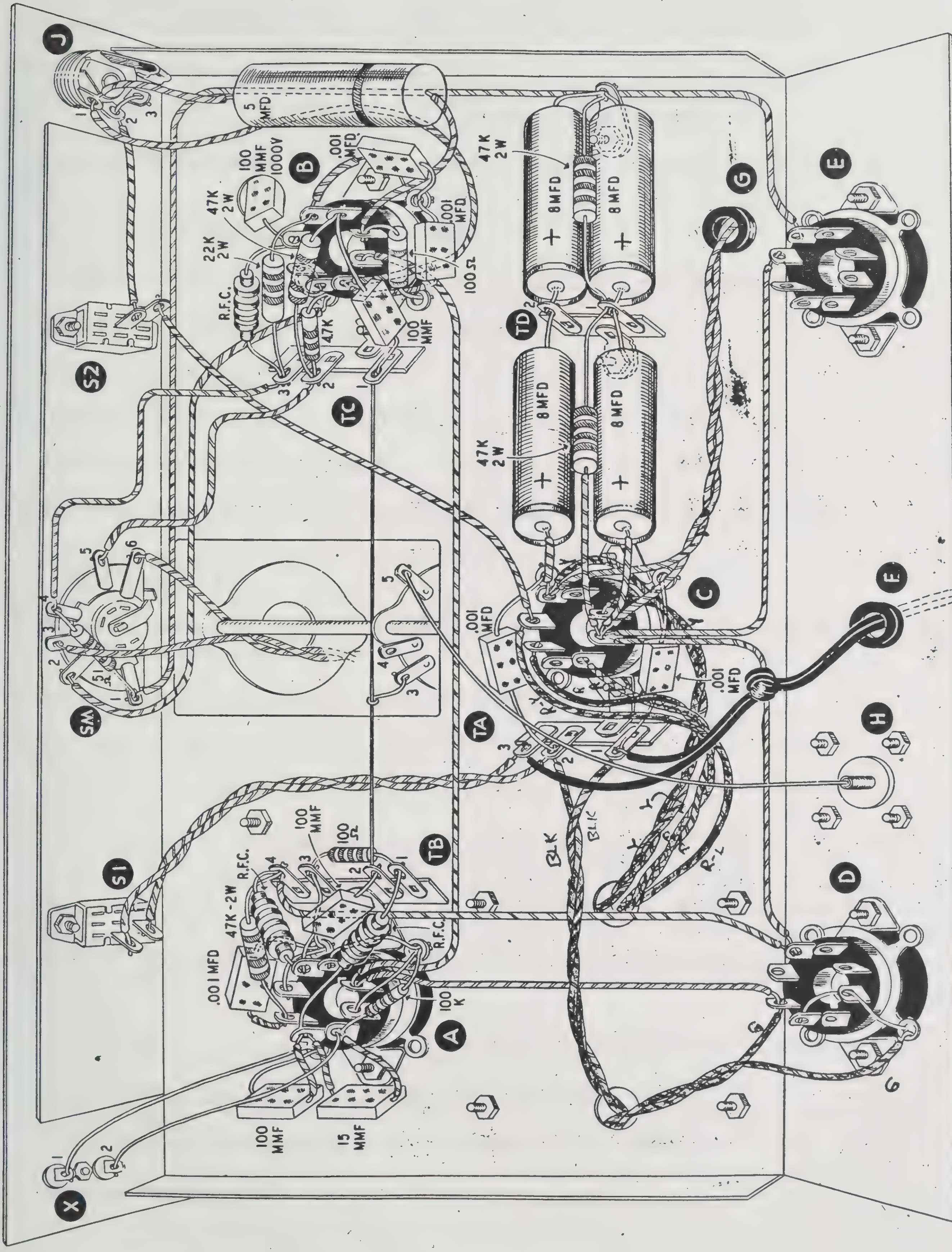
( ) Connect the other lead of this condenser to the solder lug near the chassis edge (NS).

( ) Connect a 47 KΩ 2 watt resistor between C3 (NS) and TD1 (NS).

( ) Connect a 47 KΩ 2 watt resistor between TD1 (S) and the solder lug at the edge of the chassis (S).

( ) Connect a wire from C3 (NS) to D4 (NS).

( ) Connect a wire from C3 (S) to E3 (S).



X
J
S1
S2
SW
A
B
C
D
E
F
G
H
TA
TB
TC
TD
5 MFD
8 MFD
47K 2W
100 MMF 1000V
.001 MFD
22K 2W
R.F.C.
47K
100 MMF
100 Ω
100 K
47K-2W
.001 MFD
15 MMF
BLK
R-Y

PICTORIAL 1

( ) Connect one end of a wire about 16" long to E4 (S).

( ) Run the wire around the outside edge of the chassis as shown in Pictorial 1 and connect the other end to SM1 (NS). Refer to Figure 1 or Pictorial 1 for SM1 connection.

This completes the power supply wiring.

WIRING OF THE OSCILLATOR TUBE

Note: For best operation and ease of construction, parts should be placed as shown in Pictorial 1.

( ) Connect a wire from D4 (S) to TB4 (NS).

( ) Connect a piece of light bare wire to A3 (S). Pass the wire through AG1 (NS) to A1 (S).

( ) Connect a 100 KΩ resistor from A4 (NS) to AG1 (S).

( ) Connect a piece of light bare wire from A7 (S) to AG4 (NS).

CAUTION: Do not use 6 1/2" length of heavy bus wire until called for.

( ) Connect a heavy bare wire from X1 (S) to AG3 (NS). See Pictorial 1.

( ) Connect a .001 μfd mica condenser from A6 (use sleeving) (NS) to AG4 (NS).

( ) Connect one end of a 100 μμf mica condenser to AG3 (S). Connect the other end to A5 (NS). (Use sleeving.)

( ) Connect one end of a 15 μμf mica condenser to A5 (NS). (Use sleeving.) Connect the other end to A4 (NS). (Use sleeving.)

( ) Connect a heavy bare wire from X2 (S) to A4 (S). See Pictorial 1.

( ) Connect an RF choke from A5 (S) to TB1 (NS).

( ) Connect a 100 Ω 1/2 watt resistor from TB1 (S) to TB3 (NS).

Note: At this point, the builder has two choices in the method of keying the transmitter. In the interest of stability, it is recommended that only the amplifier stage be keyed. However, it may be wired so that both the amplifier and oscillator stage can be keyed simultaneously for break-in operation. If it is desired to key only the amplifier, connect a short bare wire from TB3 (S) to AG4 (S). If both stages are to be keyed, connect a .001 μfd condenser from TB3 (NS) to AG4 (S) in place of the bare wire; then, connect a wire to TB3 (S). Run this wire along the front edge of the chassis to J1 (NS). All wiring instructions that follow apply for either method of keying.

( ) Connect a 47 KΩ 2 watt resistor from A6 (S) to TB4 (NS).

( ) Connect the single pi 90 μh RF choke from A8 (NS) to TB4 (S).

( ) Connect a 100 μμf mica condenser from A8 (S) to TB2 (NS).

This completes the oscillator tube wiring.

AMPLIFIER TUBE WIRING

( ) Connect a light bare wire from B1 (S). Pass the wire through B2 (S) to BG1 (NS).

( ) Connect a 4.7 KΩ resistor from TC2 (NS) to BG1 (NS).

( ) Connect a .001 μfd mica condenser from BG3 (NS) to B4 (NS). (Use sleeving.)

( ) Connect a .001 μfd mica condenser from BG3 (S) to B8 (NS). (Use sleeving.)

( ) Connect a wire from B8 (S) to J1 (NS).

(√) Connect the outside foil of a .5 μfd paper condenser to B6 (NS). (Use sleeving.) See Pictorial 1 for mounting position.

( ) Connect the other end of the condenser to J1 (S). (Use sleeving.)

( ) Connect a 100 Ω 1 watt resistor from B6 (S) to BG4 (S).

( ) Connect a 100 μμf mica condenser from TC1 (NS) to B5 (NS).

( ) Connect a 47 KΩ 2 watt resistor from B5 (S) to TC2 (NS).

( ) Connect a wire from TC2 (S) to SM5 (S).

( ) Connect a wire from SM2 (S) to BG1 (S). Run the wire along the front of the chassis.

( ) Connect a 22 KΩ 2 watt resistor from B4 (S) to TC3 (NS).

( ) Connect a 100 μμf 1,000 volt mica condenser to B3 (NS). Pass this condenser through the hole in the chassis adjacent to the tube socket so that the insulated part of the condenser is centered in the hole. Leave the other end free. See Pictorial 1.

( ) Connect an RF choke between B3 (S) and TC3 (NS).

( ) Connect a wire from TC3 (S) to SM4 (NS).

( ) Connect a 51 Ω 1 watt 5% resistor from SM1 (S) to SM4 (S).

This completes the amplifier wiring.

COIL ASSEMBLY AND WIRING

( ) Mount the oscillator coil as shown in Figure 2 placing a solder lug under the head of the screw. Use a lockwasher and nut on the underside of the chassis.

( ) Mount the oscillator and amplifier variable tuning condensers CO and CA on the panel as shown in Figure 2, using ~~round head 6-32 screws~~. a control lockwasher behind the panel and a control flatwasher and nut on the front. see fig 3 for parts.

( ) Examine Pictorial 2 carefully, noting the terminal positions of the band switch SB and mount on the panel as shown in Pictorial 2 omitting the lockwasher. Use a flatwasher and nut on the front of the panel and do not tighten the nut yet.

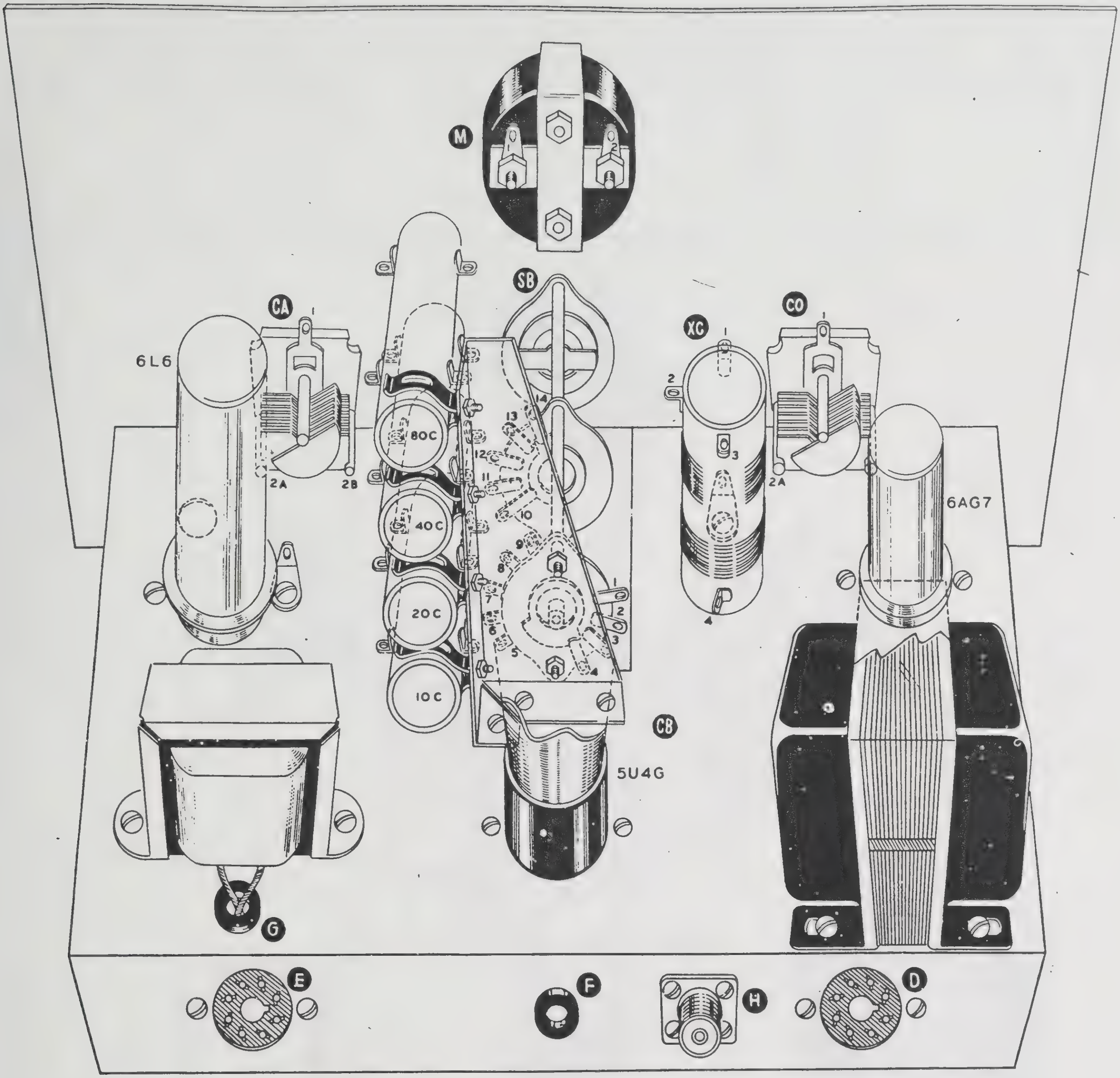


Fig. 2

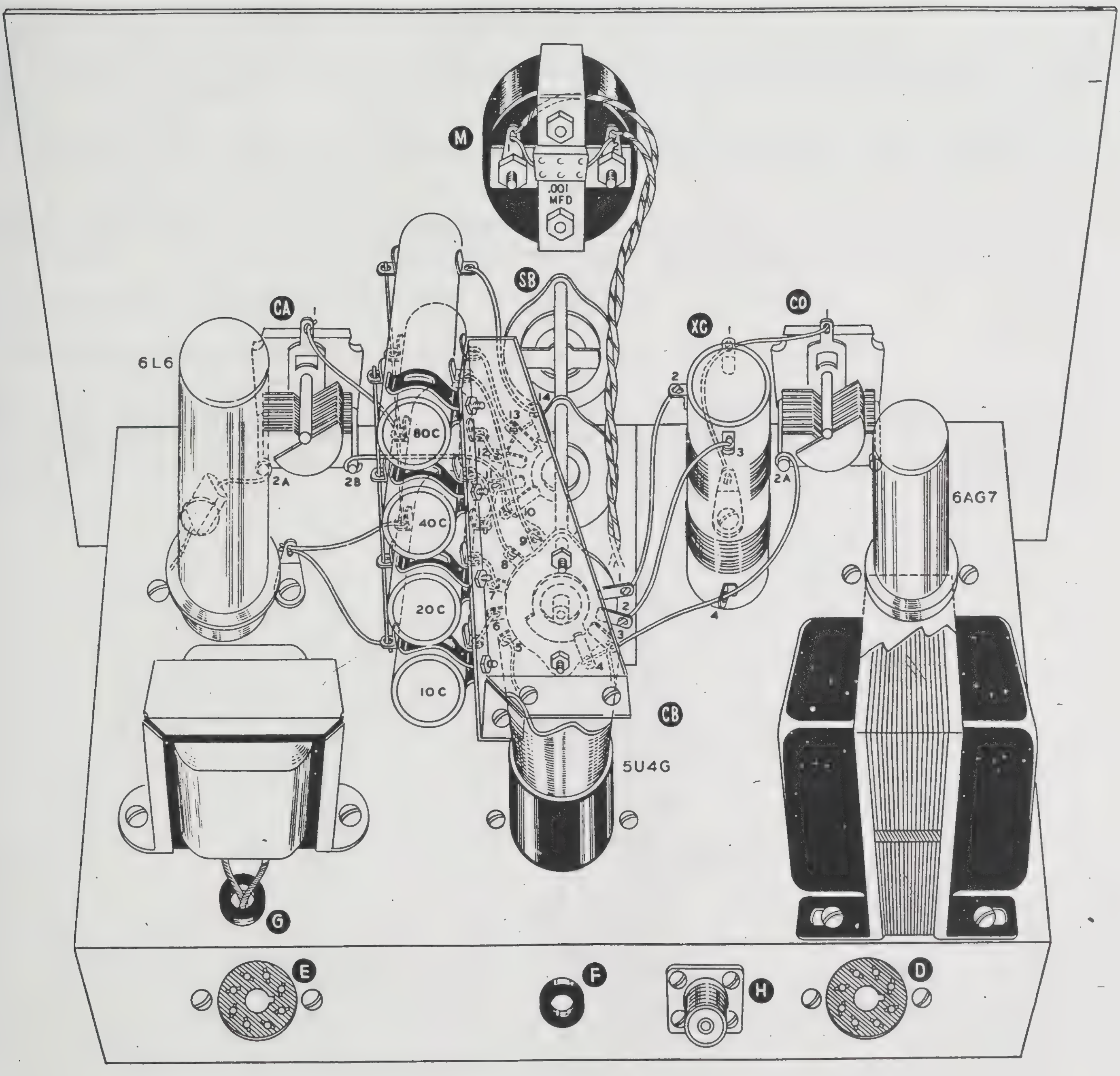
( ) By referring to Figure 2 and Pictorial 2, you will note that the coil bracket CB anchors the rear end of the band switch as well as supporting the amplifier coils. Slide the holes in the flat portion of the coil bracket over the two screws protruding from the rear of the band switch and secure using 5-40 nuts and lockwashers furnished.

( ) Now align the three holes in the base of the coil bracket with the holes in the chassis and mount the coil bracket to the chassis using 6-32 screws, nuts, and lockwashers.

( ) Tighten the 3/8" band switch nut.

( ) Mount the four coil clamps on the coil bracket as shown in Figure 2.

( ) Mount the meter through the large hole at the top of the panel and secure the meter to the panel by means of the clamp furnished. Be sure to align the meter square with the panel before tightening the clamp.



PICTORIAL 2

Note: The wiring of the oscillator and amplifier coils is somewhat difficult due to the large size wire used. The work may be performed from both the top of the chassis and through the large hole from the bottom. Care taken at this point will result in neatness and operating efficiency.

( ) Connect a wire from SM3 (S) to + meter M1 (NS).

( ) Connect a wire from SM6 (S) to - meter M2 (NS).

( ) Connect a .001 μfd mica condenser from M1 (S) to M2 (S).

( ) Connect a heavy tinned wire from CO1 on the oscillator tuning condenser (S) to XC1 on the oscillator coil (NS).

( ) Connect a heavy tinned wire from XC1 (S) on the oscillator coil to the solder lug under the coil mounting screw (S).

( ) Run a heavy tinned wire from SB4 on the band switch (S) through terminal XC4 on the oscillator coil to terminal CO2A on the tuning condenser. Solder XC4 and CO2A.

( ) Connect a heavy tinned wire from SB2 (S) to XC3 (S).

( ) Connect a heavy tinned wire from SB1 (S) to XC2 (S).

Note: The amplifier coils may be identified by the number of turns on each. The 10 meter coil 10C having the least turns, and the 80 meter coil 80C having the most. The coils 20C, 40C, and 80C have condensers connected across the terminals 1 and 2. See Figure 5 for mounting details.

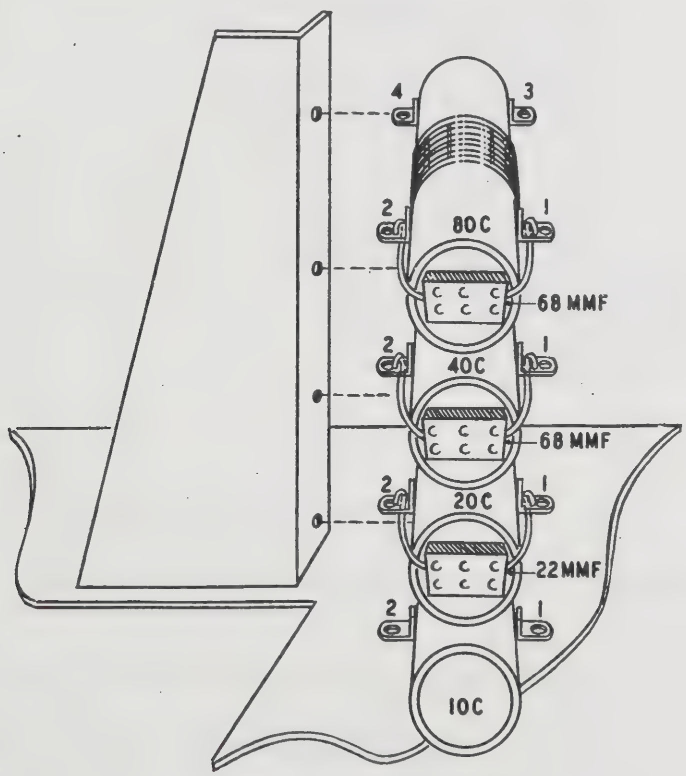


Fig. 5

( ) Connect a 22 μμf 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 20C (NS).

( ) Connect a 68 $\mu\mu$f 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 40C (NS).

( ) Connect a 68 $\mu\mu$f 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 80C (NS).

( ) Insert the 10 meter coil 10C in the lowest coil clamp. Connect a heavy tinned wire from 10C2 to SB11. Align the coil straight and parallel to the chassis; then solder the connections.

( ) Connect a short heavy tinned wire from 10C4 (S) to SB6 (S).

( ) Insert the 20 meter coil 20C in the next higher coil clamp.

( ) Connect a short heavy tinned wire from 20C2 to SB12. Observe the same precautions as with the 10 meter coil and solder the connections.

( ) Connect a short heavy tinned wire from 20C4 (S) to SB7 (S).

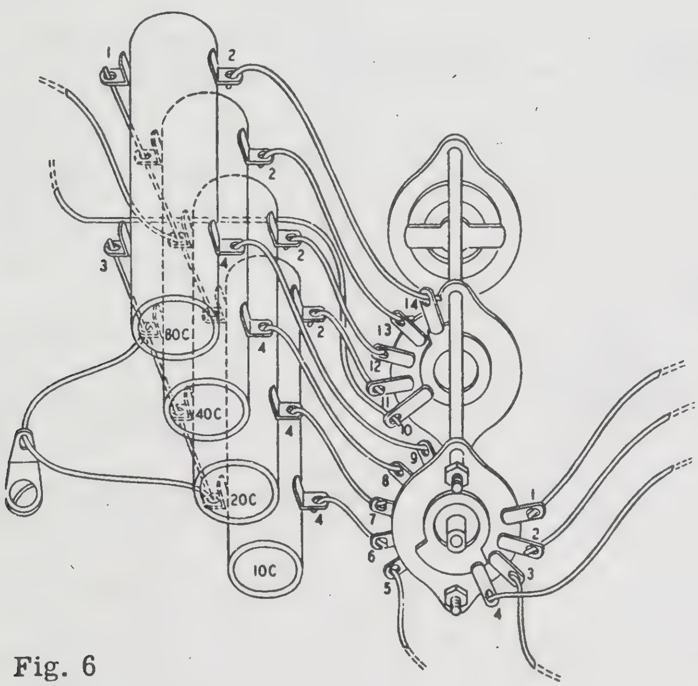


Fig. 6

( ) Insert the 40 meter coil 40C in the next coil clamp.

( ) Connect a short heavy tinned wire from 40C2 to SB13. Align the coil and solder the connections.

( ) Connect a short heavy tinned wire from 40C4 (S) to SB8 (S).

( ) Insert the 80 meter coil 80C in the top coil clamp.

( ) Connect a short heavy tinned wire from 80C2 to SB14. Align and solder.

( ) Connect a short heavy tinned wire from 80C4 (S) to SB9 (S).

( ) Run a heavy tinned wire through the #1 terminals of all the coil. See Pictorial 2 and Figure 6.

( ) Solder connections 80C1 and 40C1.

( ) Connect one end of a heavy tinned wire to SB10 (S). Run this wire around coil 10C to CA2B on the tuning condenser (S). See Figure 6.

( ) Connect the end of the 100 $\mu\mu$f condenser coming through the chassis to CA2A (S).

( ) Run a heavy tinned wire from CA1 on the amplifier tuning condenser to 20C1. Solder CA1 and 20C1.

( ) Run a heavy tinned wire through all the #3 terminals on the coils. Solder all connections but 10C3.

( ) Run a heavy tinned wire from 10C1 through the solder lug adjacent to the tube socket to 10C3. Solder all connections.

( ) On the bottom side of the chassis run the 6 1/2" length of bus between TB2 (S) and TC1 (S).

( ) Connect a heavy tinned wire to SB3 (S). Run this wire clear of terminal SB4 to the bus wire just installed. Make a firm connection to this bus and solder.

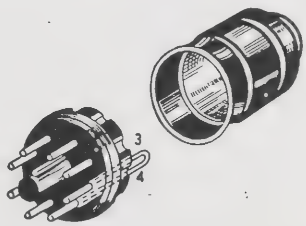
( ) Run a heavy tinned wire from SB5 down through the large hole in the chassis to the center terminal of the coax jack H. Arrange wire to clear all components and solder the connections. See Pictorial 1.

( ) Insert the AC line cord through the grommet F in the rear of the chassis. Tie a knot in the cord about 3" from the end.

( ) Connect one end of the cord to TA1 (S).

( ) Connect the other end to TA3 (S).

Fig. 7



( ) On the male octal plug furnished, connect a jumper from pin 3 to pin 4 (S). See Figure 7.

( ) Install the two round knobs on the tuning condensers. Align the pointers in such a manner that the pointer reads 100 when the condenser is fully meshed (maximum capacity).

( ) Install the pointer knobs on the band and meter switch. Tighten the set screw on the flat part of the switch shaft.

This completes the wiring of your Heathkit Model AT-1.

TRANSMITTER

TESTING THE TRANSMITTER

CAUTION: VOLTAGES DANGEROUS TO LIFE ARE PRESENT ON THIS TRANSMITTER. USE EXTREME CARE WHEN TRANSMITTER IS OUT OF CASE.

Before testing the transmitter, recheck all wiring. Damage to components may result due to errors in wiring.

( ) Insert an 80 meter crystal in the crystal socket.

( ) Plug a key into the key jack.

( ) Turn the STANDBY switch off and the OFF-ON switch on. Allow about two minutes for warmup.

( ) Turn the band switch to the 80M position and the meter switch to GRID position.

( ) Turn the STANDBY switch to PLATE-ON position and depress the key momentarily. The meter should indicate a low value of current. Release key.

( ) Turn the meter switch to the PLATE position and again depress the key. The meter should read a high value of current. Quickly tune the control marked OUTPUT. The meter should show a pronounced dip. Release key.

( ) Turn the band switch to the 40M position and the meter switch to the GRID position.

( ) Depress the key and tune the DRIVER control for maximum indication on the meter. Release key.

( ) Turn meter switch to the PLATE position and depress key. Tune the OUTPUT control for a pronounced dip. Release key.

( ) Repeat the last two steps on the 20 and 10 meter bands. If the results obtained are similar to those described above, the transmitter is operating correctly and may be installed in the cabinet. If not, refer to the section on trouble-shooting in the back part of this manual.

( ) Install the rubber feet on the cabinet. See Figure 8.

( ) Slide the transmitter into the cabinet being careful not to damage any of the components.

( ) Attach the transmitter to the cabinet by means of the two sheet metal screws in the rear and the eight sheet metal screws in the panel.

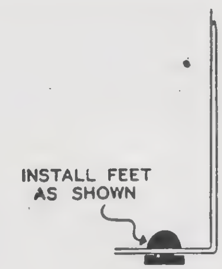


Fig. 8

This completes the transmitter.

COUPLING THE TRANSMITTER TO THE ANTENNA

Almost any piece of wire may be made to radiate when a source of RF power is connected to it. However, this does not mean it will radiate well and if an antenna is constructed based on this supposition, it is quite likely you will not get out of your backyard.

The results obtained with any transmitter are more dependent upon the antenna and the coupling system than upon the power input to the transmitter. Consequently, the effort applied to the design and installation of an efficient antenna system and the care taken in matching this system to the transmitter will be well worth the time and trouble taken.

It is not within the scope of this manual to go into a complete description of all types of antennas and coupling systems. Therefore, we will describe only a few basic types of antennas and coupling systems. For more detailed descriptions of antenna systems, the reader is referred to the handbooks published by amateur radio organizations.

END FED-HERTZ AND MARCONI

This consists merely of a single wire from 1/4 wave length long to any even multiple thereof. One end of the wire is coupled to the transmitter and the other end supported as free in space as possible. If this antenna is operated against ground, it is known as a MARCONI antenna. Its greatest disadvantage is due to the necessity of bringing part of the radiating element into the radio room where its proximity to nearby objects increases losses. Its greatest advantage is its simplicity and compact size where space is at a premium. See Figures 9 and 10.

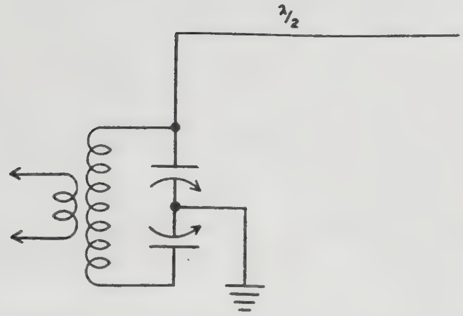


Fig. 9

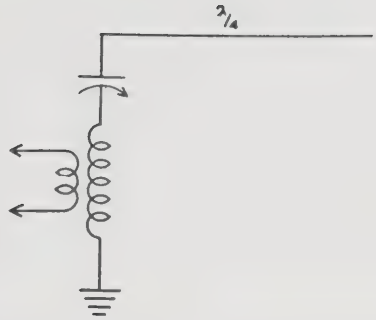


Fig. 10

In Figure 9 the coil and condenser combination should be capable of tuning to the transmitter output frequency. In Figure 10 the condenser should have a large capacity and the coil tapped to allow for any length of antenna.

END FED-ZEPP, DIPOLE, AND FOLDED DIPOLE ANTENNAS

In the average station, it will be found expedient to have the radiating portion of the antenna some distance from the transmitter. This statement assumes that the amateur will have his antenna up high and clear of nearby objects, whereas, the actual transmitter may be in the basement or any other room in the house. In this case, some form of transmission line must be used to efficiently connect the transmitter to the antenna.

There are two basic types of transmission lines; the untuned, non-resonant, or "flat" line, and the tuned, resonant line. The untuned line may be made any length within reason providing it meets all requirements of a non-resonant line. These requirements are quite critical. The untuned line must be physically symetrical throughout its length and must be terminated in its characteristic impedance. In general, it is a one band antenna as the terminating impedance of the antenna will not remain the same for operation on other bands. The untuned line has a standing wave ratio (SWR) of 1 to 1. More will be said about standing waves later.

The resonant or tuned transmission line is the type more generally used when it is desired to operate an antenna on several harmonically related bands. In this type of transmission line, standing waves are usually always present to some degree. They should be kept to a minimum.

STANDING WAVES: When energy is applied to one end of a transmission line, it flows out along the line from the source to the terminating point. In this case, the antenna. If the impedance of the terminating point exactly matches the surge impedance of the line, the energy is absorbed as fast as it arrives at that point. If the terminating point does not match the impedance of the line, some of the energy is reflected back along the line. The ratio of energy going out along the line to the amount reflected back along the line represents the standing wave ratio (SWR).

This, in turn, is equal to the ratio of mismatch between the line and its terminating point.

TRANSMISSION LINE SURGE IMPEDANCE:

$$Z_S = 276 \text{ LOG}_{10} \frac{2S}{D}$$

S being the center to center spacing and D the diameter of the conductors measured in the same units.

This formula is for two-wire transmission lines. If coax cable is used for transmission line, the impedance is governed by the type used. This impedance being fixed in the manufacturing process. The impedance of an unknown coax line may be calculated from the following formula.

COAX IMPEDANCE:

$$Z_0 = 138 \log_{10} \frac{D_1}{D}$$

D_1 being the inside diameter of the outer conductor. D the outside diameter of the inter-conductor measured in the same units.

The antenna systems mentioned at the beginning of this section all use some form of transmission line, either coax or two-wire line can be used on any of them but may not be as well suited to one as to the other.

The Zepp antenna, which is an End Fed type capable of multi-band operation, is usually used with the two-wire tuned line. It has been the "hams" old standby for many years and is ideally suited where one end of the antenna is in the vicinity of the transmitter. It is tuned either in series or parallel depending upon the electrical length of the transmission line. The Zepp antenna may be coupled to the transmitter as shown in Figure 11.

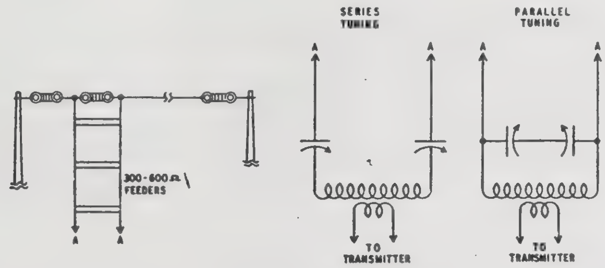


Fig. 11

The dipole, sometimes incorrectly called a Center Fed Zepp, consists of two quarter wave elements with the transmission line connected at the electrical center. The characteristic impedance of this type antenna is approximately 72 ohms and, as such may be used with 72 ohm coax to form a non-resonant line providing the electrical length of the antenna proper is exactly matched to the frequency operated.

As previously stated, this form of transmission line tends to limit the antenna to one-band operation. Consequently, the center fed antenna is usûally fed with a two-wire resonant system and is tuned in the same manner as shown in Figure 11 for the end fed Zepp antenna.

The folded dipole antenna is ideally suited to flat line operation and although this again presents the single band characteristic, it probably represents the easiest method for the beginning amateur to get on the air. The characteristic impedance of the folded dipole is approximately 300 ohms, which just happens to be the surge impedance of the "twin-lead" used in TV work. Thus, by using "twin-lead" for the flat top part of the antenna and more of the same for the transmission line, we have our antenna ready to radiate. The method of doing this is illustrated in Figure 12.

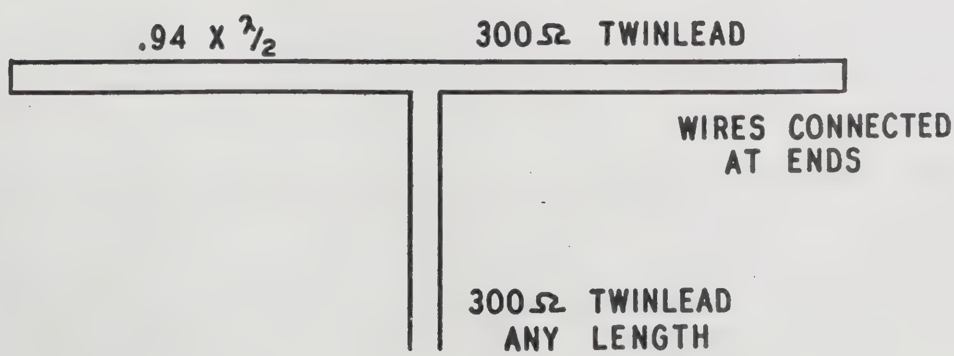


Fig. 12

The two wires of the "twin-lead" are shorted at the ends, and one of the wires is opened at the center to form the flat top. Another piece of "twin-lead" is connected to the open center wires to form the transmission line. It is recommended that transmitting type "twin-lead" be used. Antennas of this type are available commercially.

ANTENNA FORMULA

One Wave Length in Space $= \frac{300{,}000}{F_{kc}}$ Meters

Center Fed Dipole One Half Wave Long - Length in feet $= \frac{468}{F_{mc}}$

Folded Dipole One Half Wave Long - Length in feet $= \frac{462}{F_{mc}}$

Zepp Antenna One Half Wave Long - Length in feet $= \frac{492}{F_{mc}}$

ANTENNA COUPLER

The antenna coupler must meet one main requirement. It must match the transmission line to the output of the transmitter. It must also serve as a method of variable coupling between the antenna and the RF amplifier, if this has not been taken care of in the transmitter. It helps to eliminate TVI by the suppression of harmonics.

Basically, the antenna coupler is an impedance transformer, transforming the relatively high impedance output of the transmitter to the low impedance of the transmission line. The additional tuned circuit it incorporates tends to suppress harmonics present in the transmitter output. It may be placed some distance from the transmitter for convenience of connecting to the transmission line, providing coaxial cable is used to couple it to the transmitter. The AT-1 is equipped for coaxial coupling to the antenna coupler. See Figure 13 for details.

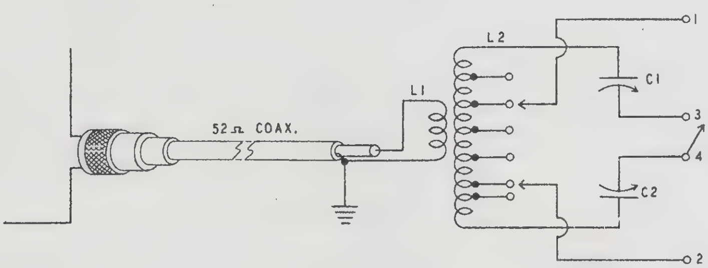


Fig. 13

The coil L1 should match the impedance of the coax cable as closely as possible at the frequency operated and the spacing between it and L2 should be adjustable to control the antenna loading.

The circuit consisting of L2, C1, and C2 must be capable of tuning to the transmitter frequency. If it is desired to series tune the antenna, the shorting bar between 3 and 4 is opened and the transmission line connected at these points. For parallel tuning, 3 is shorted to 4 and the transmission line connected to 1 and 2. Taps are provided on the coil L2 to facilitate matching the transmission line.

NOTE: For more complete information about antennas and coupling systems, refer to the amateur handbook.

AT-1 OPERATION ADJUSTMENTS

The AT-1 transmitter may be operated on the amateur bands of 80, 40, 20, 15, 11, and 10 meters using crystal or VFO control. Before attempting operation in any particular band, the operator should ascertain the frequency range of the desired band and the type of emission permissible in any portion of that band. After the desired frequency of operation has been arrived at, the crystal frequency necessary may be found by dividing the desired frequency by the harmonic relation to the crystal fundamental.

It is possible to operate the 10 meter band from an 80 meter crystal operating on its 8th harmonic but it is advisable to use 40 meter crystals for operation in the bands from 20 to 10 meters.

A VFO may be used to control the transmitter by plugging the output of the VFO into the crystal socket. If a VFO is used, care should be taken to ascertain that the VFO output is within the band, particularly on the higher frequencies where the error will be multiplied.

80 METER OPERATION

NOTE: All adjustments should be made quickly as the tubes draw excessive current when their associated circuits are not in resonance.

It is assumed that the proper antenna and coupler is attached to the transmitter in the following paragraphs and that a key is plugged in.

Plug in a crystal with a frequency between 3,500 and 4,000 kc. Turn on power switch and allow transmitter to warm up for a short time. Leave STANDBY switch in STANDBY position. Turn the meter switch to the PLATE position. Turn on STANDBY switch, depress key and quickly tune OUTPUT control for a dip. It is not necessary to adjust the DRIVER control on this band.

While holding key depressed, tune antenna coupler for a rise in plate current. As the antenna is tuned for increased current, continuously adjust OUTPUT control for resonance as indicated by a dip in current. A point should be reached where the meter will still show a dip when tuned through resonance, but at a considerably increased current.

The final current reading with the antenna and transmitter both tuned to resonance should be about 60 to 80 milliamperes. If it is much lower than this, the antenna coupling should be increased. If a point is reached where it is no longer possible to dip the plate current, the antenna is over-coupled and the coupling should be reduced.

40 METER OPERATION

Plug in a crystal in the frequency range between 3,500 and 3,650 kc and turn meter switch to GRID position. Turn STANDBY switch to on, depress key and quickly tune DRIVER control for maximum meter reading. Release key. Turn meter switch to PLATE position, depress key and tune for dip. Tune antenna as outlined under 80 meter operation.

20, 15, 11 AND 10 METER OPERATION

The method of tuning for these bands is exactly the same method as for the 40 meter band, except for the choice of crystal frequencies. The 15 meter and 11 meter bands are operated on the 10 meter position of the band switch. Below is a chart of crystal frequencies necessary for operation in any of the amateur bands.

WARNING: The frequencies listed cover the entire band limits. It is not advisable to operate near the band edge. When operating in the 15 meter band with a crystal frequency near 5250 kc, it is possible to tune to the 6th harmonic. As the 6th harmonic of that crystal is outside of any of the amateur bands it should be avoided. In any case, where two dips are noted when tuning the OUTPUT control, the one giving the most pronounced dip is the correct tuning.

80 METERS	40 METERS	20 METERS
3700-3750	7150-7200	
3500 to 4000 kc	7000 to 7300 kc	14000 to 14350
Crystal	Crystal	Crystal
3500 to 4000 kc	3500 to 3650 kc	3500 to 3587.5 kc 7000 to 7175 kc

15 METERS	11 METERS	10 METERS
21100-21250		
21000 to 21450 kc	26960 to 27230 kc	28000 to 29700 kc
Crystal	Crystal	Crystal
5250 to 5362.5 kc	6740 to 6807.5 kc	3500 to 3712.5 kc 7000 to 7425 kc 14000 to 14850 kc

Crystals operating between any of the figures listed above can be used for operating the AT-1 in the band they are listed under.

RADIO TELEPHONE OPERATION

NOTE: Phone operation is limited to certain parts of the amateur bands only. It is also restricted to certain grades of amateur licenses. This must be taken into consideration before operating the AT-1 as a phone transmitter.

Modulation of a transmitter involves several factors not present in CW operation. For example, the load presented by the radio frequency amplifier must match the output impedance of the modulator. The modulator must have an impedance matching device, such as a transformer with the proper ratio to match the load resistance of the modulator tubes to the radio frequency load. The modulator must be capable of an audio output equal to 1/2 the power input to the radio frequency amplifier for 100% modulation. Some form of microphone and speech amplifier is necessary and the modulator for amateur use should reject audio frequencies above 3,000 cycles per second.

Frequencies above 3 kc are not necessary for the transmission of intelligent speech. Therefore, any frequencies above this figure not only waste usuable power but cause interference to other stations by increasing the band width of the transmitted signal.

MODULATOR DESIGN

The method of calculating the load impedance presented by the radio frequency amplifier when plate modulated is given by the formula:

$$Z_m = \frac{E_b \times 1000}{I_p}$$

where E_b is the amplifier plate voltage and I_p is the amplifier plate current in milliamperes. In the case of a screen grid tube, such as the 6L6 used in the AT-1, both plate and screen are modulated, so I_p used in the formula represents the total current for both plate and screen grid. EXAMPLE: AT-1 transmitter operating with 400 volts on the plate and 80 MA total plate and screen grid current:

$$Z_m = \frac{400 \times 1000}{80} = 5000\ \Omega \text{ Load Impedance}$$

Power input to the amplifier is expressed by the formula:

$$\text{Power In Watts} - E_b I_p$$

E_b is the amplifier plate voltage and I_p is the amplifier plate current in amperes.

As we require half the audio power output that we have RF power input, the audio requirements under the operating conditions stated above will be:

$$\text{Audio output in watts} - .5 \times 400 \times .080 \text{ or } 16 \text{ watts}$$

From the tube table it is found that push-pull 6L6's operating class AB_1 with 250 plate volts will give an output of 18 watts. The plate to plate load resistance of the tubes is found to be 5,000 ohms. Therefore, an output transformer having a 5,000 ohm primary and a ratio of total primary to secondary turns of 1 to 1 will match the modulator to the transmitter.

NOTE: This example only applies to one set of conditions, a change in the antenna loading will cause a change in RF amplifier plate current with a subsequent change in load impedance and wattage input. A different choice of modulator tubes would affect the output transformer necessary. However, from the formula given above, the modulator for any set of operating conditions may be calculated.

The reader is again referred to the amateur radio handbooks for more detailed information on the subject of phone operation.

MODULATION CONNECTIONS TO THE AT-1

In order to modulate the AT-1 transmitter, it is merely necessary to remove the jumper from pins 3 and 4 on the male octal plug, and connect the proper impedance output from the modulator transformer across these two pins. As the output of the modulator is AC, either terminal of the modulation transformer may be connected to either pin on the octal plug.

As the output impedance of the modulation transformer is more or less fixed, it is usually customary to adjust the transmitter by loading the antenna to a lesser or greater degree in order to present the proper RF load impedance to match the modulator.

VFO OPERATION

When using a VFO with the AT-1, it will be necessary to short out the cathode of the RF choke and resistor on the 6AG7. If a wire is connected from A5 to D6, an octal plug having a jumper between pins 6 and 7 may be inserted in socket D for VFO operation. If the VFO receives its power from the AT-1, its plug can be wired in the same manner.

IN CASE OF DIFFICULTY

The greatest single cause of trouble is due to wiring mistakes. First, check very carefully the transmitter wiring. Due to the large amount of bare wire used in this kit, there is a good chance that a short circuit will occur. All bare wire should be kept away from the chassis and other components.

The meter may be used to some degree in trouble shooting. In the GRID position, it indicates whether the oscillator is operating correctly and, in the PLATE position, it does the same for the amplifier stage. No deflection of the meter in either position usually indicates the trouble is in the power supply.

A voltage chart is often a good means of locating trouble. The chart below gives the voltages to be expected under normal operating conditions. All readings are DC, except where indicated. These voltages were measured with an 11 megohm input vacuum tube voltmeter. A normal variation of ±15% is to be expected. With regular voltmeters, reading may be somewhat lower.

SOCKET VOLTAGE CHART

TUBE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
5U4G	0	450	440	430AC	0	430AC	0	450
6AG7	0	6.3AC	0	-95	3.5	220	0	430
6L6	0	0	420	250	-45	0	6.3AC	0

The trouble shooting chart included at this point may also be used to good advantage in case difficulty occurs.

TROUBLE	SYMPTOMS	POSSIBLE CAUSE
Transmitter inoperative	Meter reads high current in PLATE position. No indication in GRID position.	Oscillator not oscillating due to: 1. Defective or dirty crystal. 2. Defective 6AG7 tube. 3. No voltage on oscillator plate or screen grid. (Pins 6 and 8 on voltage chart.) 4. Shorted or open circuit on oscillator coil or terminals SB1 through 4 on the band switch. 5. DRIVER control not tuned properly.
Transmitter inoperative	Meter reads in GRID position. Does not read in PLATE position.	Amplifier not drawing current due to: 1. Modulator plug not inserted in socket. 2. Modulator plug does not have jumper between terminals 3 and 4. 3. Defective 6L6 tube. 4. No voltage on plate and screen grids. (Pins 3 and 4 on the voltage chart.) 5. Cathode circuit to ground open. (Check key jack.) 6. Plate voltage supply open at meter switch. (Terminals 1 and 4 on meter switch.)
Transmitter inoperative	Meter reads in both GRID and PLATE positions. OUTPUT tuning will not dip meter current.	Amplifier will not resonate due to: 1. 100 $\mu\mu$f 1,000 volt condenser circuit open between B3 and CO2A. 2. "Tank" circuit open between CA2B and SB10. 3. Amplifier coil connections shorted. 4. Switch positions SB10 through 14 open or shorted. 5. Antenna overcoupled.
Transmitter inoperative	Meter does not read in either position.	No voltages on tubes due to: 1. Open circuit at switches S1 or S2. 2. Defective 5U4G tube. 3. Short in high voltage circuit. 4. Open circuit at SM3 or 6 on the meter switch.

Transmitter will not load when connected to an antenna.	No increase in plate current with antenna connected.	1. Short or open connections on #4 amplifier coil terminals. 2. Shorted or open connections on terminals SB5 through 9 on the band switch. 3. Antenna coupler not tuned to band being operated. 4. Inefficient antenna.

TELEVISION INTERFERENCE (TVI)

There is no single method of combating television interference that will apply to all circumstances. Each individual installation may require a different technique. However, a few hints are included here covering the usual methods of eliminating TVI.

LOW-PASS FILTER

A low-pass filter inserted in the coaxial line between the transmitter and the antenna coupler is very effective. The low-pass filter will eliminate any harmonic radiation above its cutoff frequency, usually 40 to 50 mc. The figure below describes one method of making a low-pass filter.

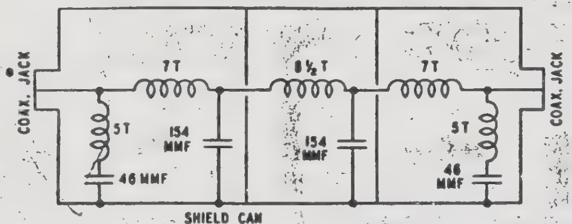


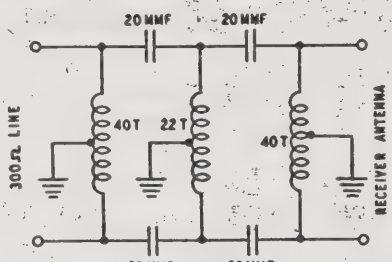
Fig. 14

Coils are wound of No. 12 or 14 wire 1/2" inside diameter, spacing 8 turns per inch.

HIGH-PASS FILTER

The high-pass filter is used where only one or two television sets are affected out of many. It must be inserted in the TV lead-in directly at the antenna terminals of the receiver. The figure below describes one method of making a high-pass filter.

Fig. 15



Coils are wound of No. 30 wire on a 1/8" diameter form.

AC LINE FILTER

It is sometimes possible that the transmitter is feeding energy from the antenna into the house wiring. This energy in turn is fed directly into the receiver through its line cord. The figure below shows a method of constructing an AC line filter for the receiver.

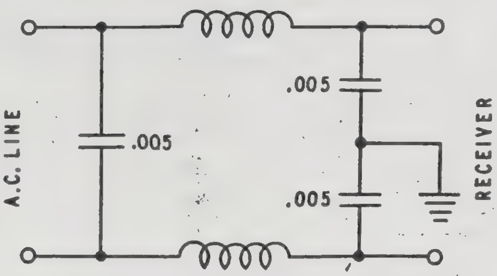


Fig. 16

The coils consist of a 2" length of close wound No. 18 wire on 1/2" diameter form.

There are numerous other methods which will help to eliminate TVI. In general, the transmitting antenna should be kept away from receiving antennas. All RF components should be shielded. Consequently, the AT-1 should be operated in the case at all times.

For further information on television and broadcast interference elimination, refer to the amateur handbooks.

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $5.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the specified performance level in your instrument. Factory repair service is available for a period of one year from the date of purchase or you may contact the Engineering Consultation Department by mail. For information regarding the possible modification of existing kits, the volumes listed in the Bibliography section are recommended. They can be obtained at or through your local library, as well as at any electronic outlet store. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for specific purposes. Therefore, such modifications must be made at the discration of the kit builder according to information which will be much more readily available from some local source.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted. Attach a tag to the instrument giving name, address and trouble experienced. Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

SPECIFICATIONS

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

WARRANTY

The Heath Company limits its warranty of parts supplied with any kit to a period of three (3) months from the date of purchase. Replacement will be made only when said part is returned postpaid, with prior permission and in the judgment of the Heath Company was defective at the time of sale. This warranty does not extend to any Heathkits which have been subjected to misuse, neglect, accident and improper installation or applications. Material supplied with a kit shall not be considered as defective, even though not in exact accordance with specifications, if it substantially fulfills performance requirements. This warranty is not transferable and applies only to the original purchaser. This warranty is in lieu of all other warranties and the Heath Company neither assumes nor authorizes any other person to assume for them any other liability in connection with the sale of Heathkits.

The assembler is urged to follow the instructions exactly as provided. The Heath Company assumes no responsibility for the operation of the completed instrument, nor liability for any damages or injuries sustained in the assembly or operation of the device.

HEATH COMPANY
Benton Harbor, Michigan

BIBLIOGRAPHY

The Radio Amateur's Handbook, A. R. R. L.
Antenna Book, A. R. R. L.
Nilson and Hornung; Practical Radio Communication

PARTS LIST

HEATHKIT AMATEUR TRANSMITTER

MODEL AT-1

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-3	1	100 Ω 1/2 watt
1-16	1	4.7 KΩ 1/2 watt
1-26	1	100 KΩ 1/2 watt
1-43A	1	51 Ω 1 watt 5%
1-17A	1	100 Ω 1 watt
1-11B	1	22 KΩ 2 watt
1-10B	4	47 KΩ 2 watt
Condensers		
20-29	1	15 $\mu\mu$f 500 volt mica
20-30	1	22 $\mu\mu$f 1 kv silver mica
20-31	2	68 $\mu\mu$f 1 kv silver mica
20-11	3	100 $\mu\mu$f 500 volt mica
20-32	1	100 $\mu\mu$f 1 kv mica
20-33	7	.001 μfd 500 volt mica
23-15	1	.5 μfd 400 volt paper
26-~~14~~ 21	2	50 $\mu\mu$f variable
25-22	4	8 μfd 350 volt electrolytic
Switches		
60-1	2	SPST slide switch
63-52	1	3 pole 3 position rotary
63-53	1	2 pole 3 position rotary
Transformers-Coils-Chokes		
54-21	1	Power transformer
46-7	1	Filter choke
45-4	2	1.1 MH RF choke
45-7	1	90 μh RF choke
40-32	1	Oscillator coil
40-33	1	80 M amplifier coil
40-34	1	40 M amplifier coil
40-35	1	20 M amplifier coil
40-36	1	10 M amplifier coil
Tubes-Meters		
407-21	1	10 MA meter
411-2	1	5U4G tube
411-8	1	6L6 tube
411-53	1	6AG7 tube
Sockets-Terminal Strips		
431-2	1	2 Lug terminal strip
431-3	2	3 Lug terminal strip
431-5	1	4 Lug terminal strip
434-38	1	Crystal socket
434-39	5	Octal tube socket
436-4	1	Phone jack
436-5	1	Coaxial jack
438-6	1	Octal plug
438-9	1	Coaxial plug

PART No.	PARTS Per Kit	DESCRIPTION
Hardware		
73-1	2	3/8" rubber grommet
208-2	4	Spring clip
250-8	10	#6 sheet metal screw
250-9	24	6-32 round head screw
~~250-7~~	~~4~~ 1	~~6-32 x 3/16 screw~~
250-18	4	8-32 round head screw
250-34	5	4-40 round head screw
252-3	24	6-32 hex nut
252-4	4	8-32 hex nut
252-7	~~3~~ 5	Control nut
252-15	5	4-40 hex nut
253-10	~~3~~ 5	Control washer
254-1	25	#6 lockwasher
254-2	4	#8 lockwasher
254-4	~~2~~ 4	Control lockwasher
259-1	3	#6 solder lug
250-22	2	Set screw
Miscellaneous		
89-1	1	Line cord
90-22	1	Cabinet
200-M49	1	Chassis M70F58 203-~~M70F58~~
203-~~M45F58~~	1	Panel
204-M47	1	Coil bracket
261-1	4	Rubber feet
340-1	1	length #14 bare wire
340-3	1	length #16 bare wire
344-1	1	roll Hookup wire
346-1	1	length Spaghetti
462-M11	2	Pointer knob
462-15	2	Round skirt knobs
595-64	1	Manual

ASSEMBLING AND USING YOUR . . . . . Heathkit

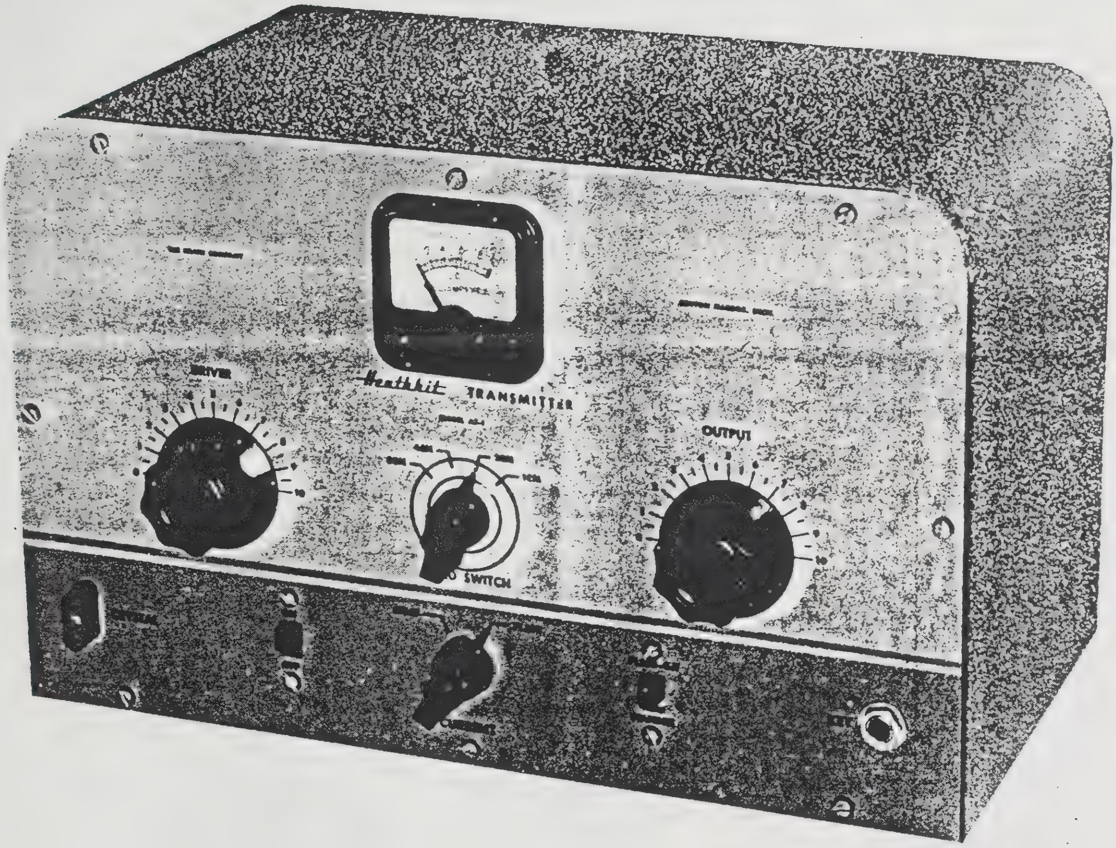
AMATEUR TRANSMITTER
MODEL AT-1

595-64

PRICE $1.00

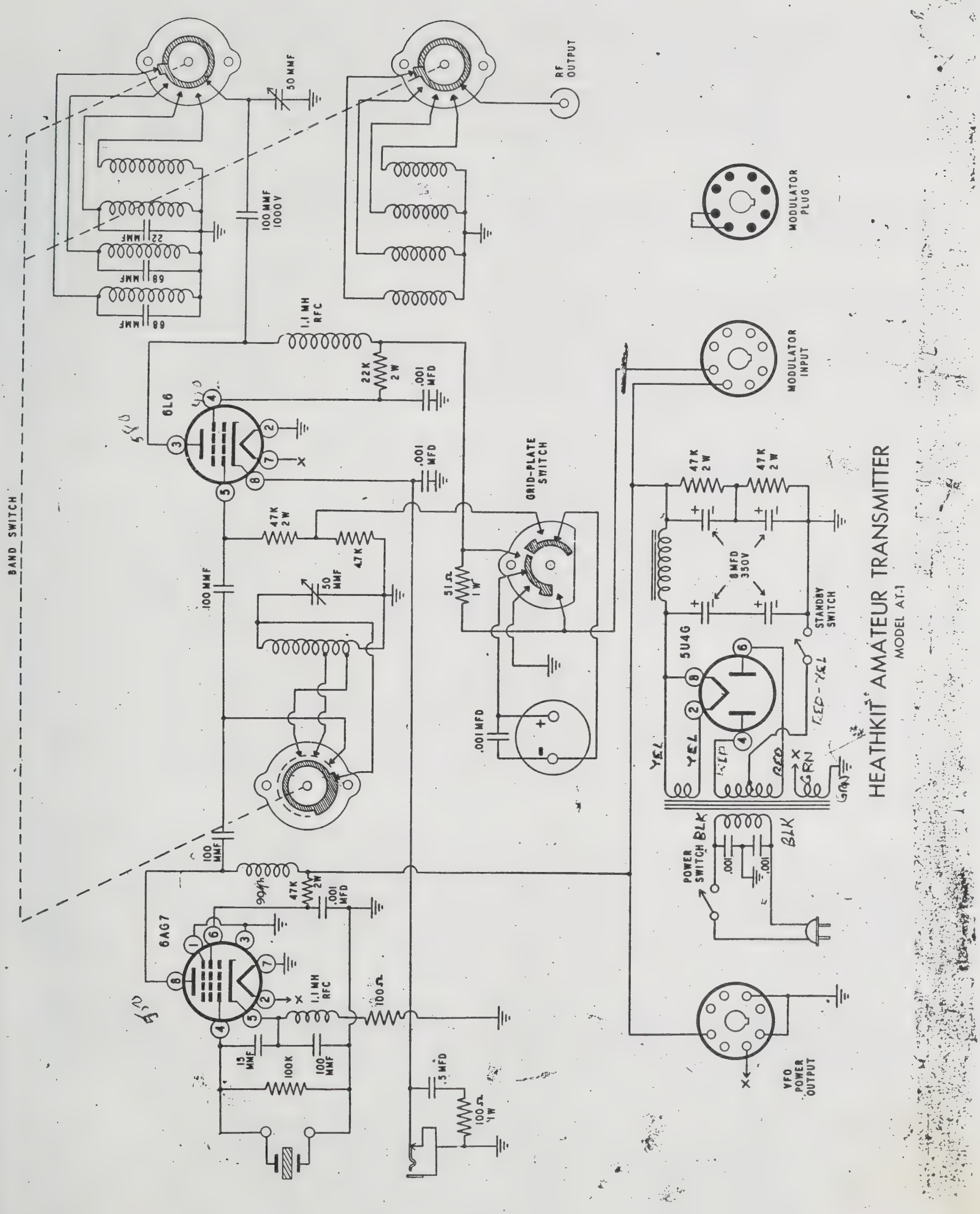
HEATH COMPANY
BENTON HARBOR, MICHIGAN

ASSEMBLY AND OPERATION OF THE
HEATHKIT AMATEUR TRANSMITTER
MODEL AT-1



SPECIFICATIONS

RF Amplifier Power Input	25-30 Watts
Output Connection	52 Ohm Coaxial Cable
Oscillator Operation	Crystal, can be operated by a VFO
Amplifier Operation	CW, can be modulated for phone
Band Coverage	80, 40, 20, 15, 11, 10 Meters
Tube Complement	
5U4G	Rectifier
6AG7	Oscillator - Multiplier
6L6	Amplifier - Doubler
Power Requirements	105-125 50/60 Cycle, 100 Watts
Cabinet Size	8 1/8" high x 13 1/8" wide x 7" deep
Net Weight	13 lbs.


HEATHKIT AMATEUR TRANSMITTER
MODEL AT-1
BAND SWITCH
50 MMF
RF OUTPUT
100 MMF 1000V
22 MMF
68 MMF
68 MMF
1.1 MH RFC
22K 2W
.001 MFD
6L6
.001 MFD
GRID-PLATE SWITCH
47K 2W
47K
100 MMF
50 MMF
51 Ω 1W
.001 MFD
MODULATOR PLUG
MODULATOR INPUT
47K 2W
47K 2W
8 MFD 350V
STANDBY SWITCH
5U4G
YEL
YEL
RED
GRN
BLK
BLK
POWER SWITCH
.001
.001
100 MMF
47K 2W
.001 MFD
6AG7
1.1 MH RFC
100 Ω
15 MMF
100K
100 MMF
.5 MFD
100 Ω 1W
VFO POWER OUTPUT

INTRODUCTION

The Heathkit Model AT-1 Transmitter was designed to provide both the beginning and experienced amateur with a simply constructed yet versatile kit form transmitter at modest cost. Consideration was also given to the probable enlarging of the operator's station. Rather than become obsolete, the AT-1 can be operated with crystal or VFO control and used as an all-band exciter for a high power final. It has provision for modulation as a low power phone transmitter and can be used directly as such or used to drive a linear amplifier in a high power phone station. For the "old timer," it makes an excellent standby transmitter while the big "rig" is being overhauled.

The transmitter incorporates the maximum permissible shielding to minimize TVI from harmonics radiated directly by the transmitter. The amplifier stage operates as a doubler on the higher frequencies to eliminate the possibility of parasitic oscillations.

Although primarily designed for crystal operation, it will perform equally well when driven by a VFO and is equipped to supply the VFO with both plate and filament power from an octal socket on the rear of the transmitter chassis. The band switching knob on the panel switches both the oscillator and amplifier coils simultaneously. This not only increases the convenience of operation but also lessens the possibility of operation on the wrong crystal or VFO harmonic. A three position meter switch provides for measurement of the amplifier grid current, amplifier plate current, and has an "off" position for use when the transmitter is being keyed.

The transmitter incorporates tried and proven tube types and circuitry, careful layout, and quality components. It will give long and reliable service when properly constructed.

CIRCUIT DESCRIPTION

The power supply is conventional. A transformer steps up the AC line voltage to approximately 400 volts, which is then converted to direct current by the action of a 5U4G full-wave rectifier tube. Ripple component present in the output of the rectifier is removed by a "brute force" filter consisting of four electrolytic condensers and a filter choke. A switch in the AC line turns the transmitter ON and OFF. Another switch in the negative return shuts off the DC power when in the STANDBY position, leaving the filaments on.

The crystal oscillator consists of a 6AG7 tube operated in a tuned or untuned Colpitts circuit. The plate circuit of the oscillator is untuned when the transmitter is operated on the 80 meter band. This prevents coupling between oscillator and amplifier coils when both are at the same frequency. On all other bands the oscillator is operated as a tuned plate amplifier or doubler stage. One set of contacts on the band switch inserts the proper oscillator coil for each band. Grid bias for the 6AG7 is obtained mainly from a grid leak resistor and partially from resistance in the cathode circuit.

The output stage consists of a 6L6 amplifier-doubler which may be operated up to approximately 30 watts input on CW or Phone. Four coils each having preadjusted antenna coupling loops are connected in turn to the 6L6 plate circuit by the action of the band switch. These coils cover the frequency range from 3.5 to 30 mc. Bias for this stage is derived from the grid current flowing through the grid resistor and is only present when the stage is being excited by the oscillator. The Grid-plate meter has its full scale sensitivity automatically changed from 10 to 100 milliamperes when switched from the grid to plate position.

Two octal sockets on the rear of the chassis provide connections for audio input and VFO power output. A coaxial jack, when used with 52 ohm coax cable, provides a shielded RF output to the antenna coupler. A .5 μfd condenser and a 100 Ω resistor across the key jack provide an effective key click filter.

NOTES ON ASSEMBLY AND WIRING

The Heathkit Model AT-1 Amateur Transmitter, when constructed in accordance with the instructions in this manual, is a high quality reliable means of communication capable of years of trouble-free service. We therefore urge you to take the necessary time to assemble and wire the kit carefully. Do not hurry the work and you will be rewarded with the pride that comes from DX contacts with a self-constructed transmitter.

This manual is supplied to assist you in every way to complete the transmitter with the least possible chance for error. We suggest that you take a few minutes now and read the entire manual through before any work is started. This will enable you to proceed with the work much faster when construction is started. The large fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the completion of the kit. These diagrams are repeated in smaller form within the manual. We suggest that you retain the manual in your files for future reference, both in the use of the transmitter and for its maintenance.

UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual to help you to identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

Read the note on soldering on the inside of the back cover. Crimp all leads tightly to the terminal before soldering. Be sure both the lead and the terminal are free of wax, corrosion, or other foreign substances. Use only the best rosin core solder, preferably a type containing the new activated fluxes, such as Kester "Resin-Five," Ersin "Multicore," or similar types.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

Resistors and condensers generally have a tolerance rating of ±20% unless otherwise stated in the parts list. Therefore a 100 KΩ resistor may test anywhere from 80 KΩ to 120 KΩ. (The letter K is commonly used to designate a multiplier of 1000.) Tolerances on condensers are generally even greater. Limits of +100% and -50% are common for electrolytic condensers. The parts furnished with your Heathkit have been specified so as to not adversely affect the operation of the finished transmitter.

In order to expedite delivery to you, we are occasionally forced to make minor substitutions of parts. Such substitutions are carefully checked before they are approved, and the parts supplied will work satisfactorily. By checking the parts list for resistors, for example, you may find that a 2.2 megohm resistor has been supplied in place of a 2 megohm as shown in the parts list. These changes are self-evident and are mentioned here only to prevent confusion in checking the contents of your kit.

We strongly urge that you follow the wiring and parts layout shown in this manual. The position of wires and parts is extremely critical in a high frequency transmitter, and changes may seriously affect the characteristics of the circuit.

STEP-BY-STEP ASSEMBLY INSTRUCTIONS

The following instructions are presented in a simple, logical, step-by-step sequence to enable you to complete your kit with the least possible confusion.

Be sure to read each step all the way through before starting. When a step is completed, check it off in the space provided. This makes it easy to resume construction after your work has been interrupted.

NOTE: We suggest that you do the following before any work is started:

1. Select from the large fold-in pictorials included with the manual the diagram showing the phase of construction you are engaged in at the time. Attach this diagram to the wall above your work space.
2. After identifying the parts from the parts list, lay them out in a large shallow box so that they are readily accessible. This will save considerable time in construction.
3. Read thoroughly the assembly and wiring instructions on the inside rear cover of the manual and refer to the general information on both inside covers of the manual to identify the parts.
4. In assembling the kit, use lockwashers under all nuts unless a solder lug is used. Tube sockets are mounted with the metal flange inside the chassis. All screws have their heads on top or outside of the chassis. This construction may be noted by referring to Figure 1. Unless otherwise stated, 6-32 screws, lockwashers and nuts are used in mounting of parts.

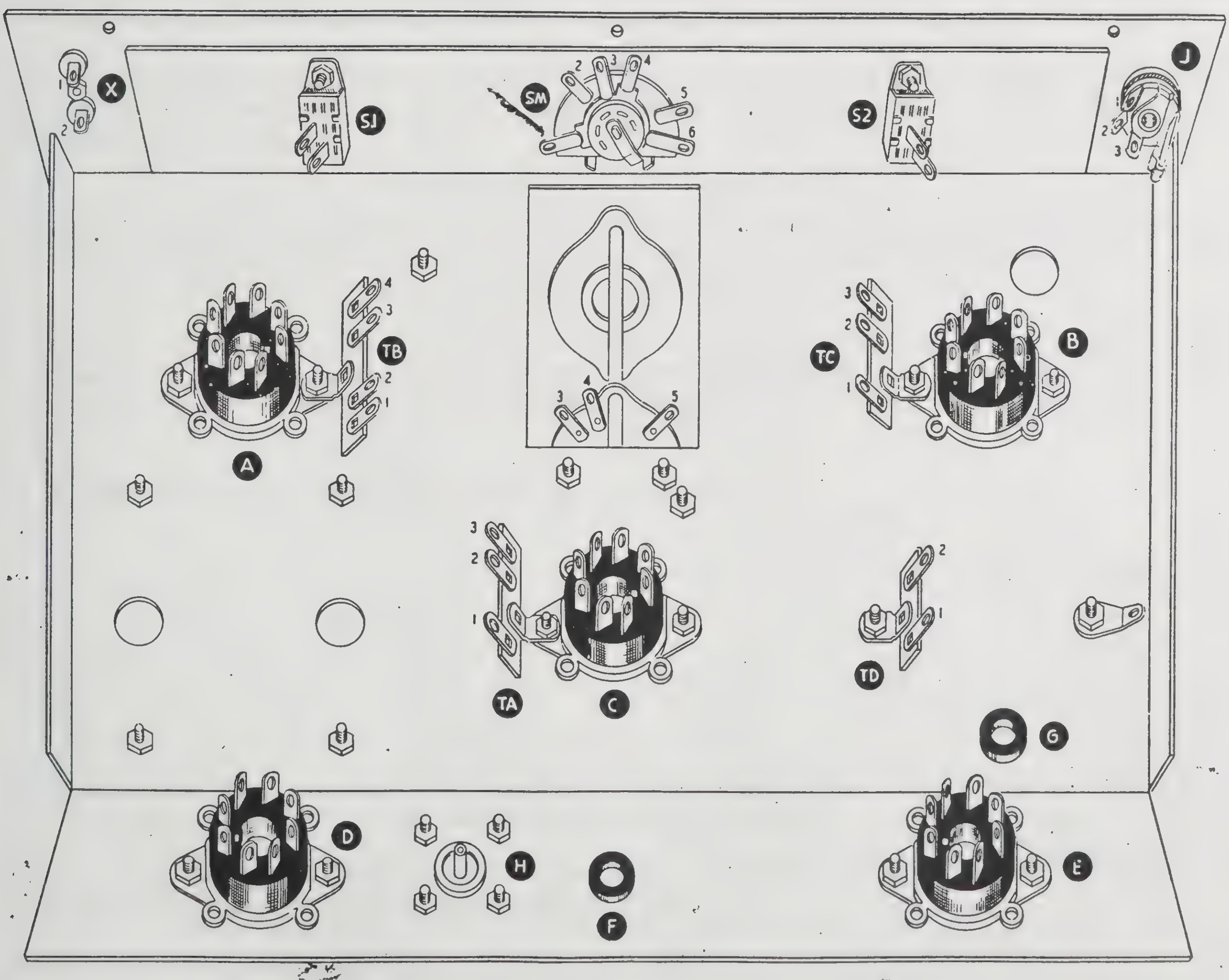


Fig. 1

CHASSIS ASSEMBLY

( ) Mount an octal socket in hole A with the keyway toward the center of the chassis. At the same time mount a four-lug terminal strip under the chassis, using the mounting screw nearest the center of the chassis. As previously stated, 6-32 screws, lockwashers and nuts are used in mounting all parts unless otherwise specified.

( ) Mount an octal socket in hole B with the keyway toward the center of the chassis. At the same time, mount a three-lug terminal strip under the chassis and a solder lug on top of the chassis, using the mounting screw nearest the center of the chassis as shown in Figures 1 and 2.

( ) Mount an octal socket in hole C with the keyway toward the right side of the chassis when viewed from the rear and a three-lug terminal strip mounted on the left hand mounting screw. Refer to Figure 1.

( ) Mount two octal sockets in holes D and E with their keyways as shown in Figure 1.

( ) Insert 3/8" rubber grommets in holes F and G.

( ) Mount the coaxial output jack in hole H using 4-40 screws and nuts.

( ) Mount the filter choke on top of the chassis with the leads over the grommet G using the two mounting holes at the right rear of the chassis. Place a solder lug under the nut nearest the edge of the chassis and a two-lug terminal strip under the other nut. See Figure 1.

( ) Mount the power transformer on top and at the left rear of the chassis, using 8-32 screws, nuts and lockwashers. Orient the transformer so that the red leads emerge nearest the center of the chassis.

ASSEMBLY OF CHASSIS TO PANEL

( ) Mount the two slide switches S-1 and S-2 with their terminal lugs in the position shown in Figure 1. The mounting screws for these switches go through both the panel and the chassis and secure the chassis to the panel. Do not tighten the screws yet.

( ) Mount the meter switch SM through the 3/8" hole in the center of the panel and chassis, using a 3/8" lockwasher behind the chassis and a 3/8" flatwasher and nut in front of the panel. Refer to Figure 1 for switch position and to Figure 3 for method of mounting controls.

( ) Align panel square with chassis and tighten screws.

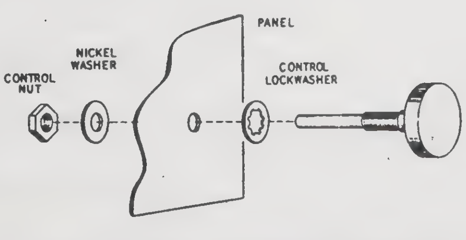


Fig. 3

( ) Mount the phone jack in the hole provided at the right bottom of the panel, using a lockwasher, flatwasher and nut. Position as shown in Figure 1.

( ) Mount the crystal holder so that the terminals protrude through the back of the panel as shown in Figure 1, using a 4-40 screw and nut.

Note: The tuning condensers and coil assembly will be mounted after the bottom of the chassis has been wired.

WIRING OF THE AT-1 TRANSMITTER

NOTE: Before beginning the wiring, refer again to the notes on wiring and soldering on the inside rear cover of the manual. We cannot stress too strongly the importance of careful wiring and soldering when applied to radio frequency circuits. In building this transmitter, you will use a considerable amount of heavy tinned wire. Both from the standpoint of neatness and efficiency, the leads should be kept short and straight. Sharp bends are to be avoided when possible and RF leads in the grid and plate circuits should be isolated as far as possible from other circuits and from each other. Soldering should be done with a great deal of care so that fluxes will not run over onto adjacent insulation; thus causing leakage and a possible loss of power.

Components are given code designations so that identification of parts on both the diagrams and on the written matter is easily defined. The tube sockets are numbered A to E inclusive and correspond to the mounting holes referred to previously under assembly instructions. It is recommended that the tube sockets be marked in pencil on the bottom of the chassis, A to E.

Switches are designated as S-1, S-B, etc. Other parts are referred to in a similar manner which will be readily apparent as the work progresses. Octal sockets are numbered in a clockwise direction, starting from the left of the keyway when viewed from the bottom. The grounding lugs attached to the sockets are numbered in the same way. See Figure 4.

Thus a connection to B5 means terminal 5 counted in a clockwise direction from the keyway on socket B. Similarly, AG-3 is the number 3 ground lug measured in the same manner on socket A.

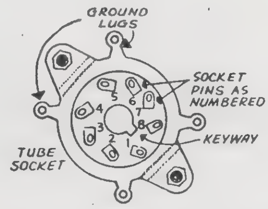


Fig. 4

Leads on resistors, condensers and transformers are generally much longer than they need to be to make the indicated connections. In these cases, the excess leads should be cut off before the part is added to the chassis. Not only does this make the wiring much neater, but in radio frequency work the excess length of the lead may actually create tuned parasitic circuits at undesired frequencies.

Wire is to be insulated unless otherwise specified. Insulated sleeving is to be used on bare wires when called for.

WIRING OF POWER SUPPLY

(S) means solder. (NS) means do not solder yet.

NOTE: Refer to the schematic and to Pictorial 1 for the following wiring.

( ) Connect a .001 μfd condenser from TA1 (NS) (use sleeving) to CG1 (S). See Pictorial 1.

( ) Connect a .001 μfd condenser from TA2 (NS) (use sleeving) to CG4 (S).

( ) Twist the red leads from the power transformer together and connect one red lead to C4 (S).

( ) Connect the other red lead from the transformer to C6 (S).

( ) Connect the red-yellow lead from the transformer to C7 (NS).

( ) Twist the yellow leads from the transformer together and connect one yellow lead to C2 (S).

( ) Connect the other yellow lead from the transformer to C8 (NS).

( ) Twist the green leads from the transformer together and connect one green lead to D2 (NS).

( ) Connect the other green lead from the transformer to DG4 (NS).

( ) Twist the black leads from the transformer together and connect one black lead to TA1 (NS).

( ) Connect the other black lead to TA2 (NS).

( ) Twist together two pieces of hookup wire about 7" long. Strip the insulation from one pair of ends and connect to the terminals of S1 (S).

( ) Run the twisted pair of leads close to the chassis to terminals TA2 and TA3. Cut wire to proper length and connect either one to TA2 (S) and the other to TA3 (NS).

( ) Connect a lead from A2 (NS) to D2 (S).

( ) Run a piece of light bare wire from D1 (S) through D7 (S) to DG4 (S).

( ) Connect a wire from C7 (S) to either terminal on switch S2 (S).

( ) Connect a wire from the other switch terminal (S) to J2 (NS) on the phone jack.

( ) Connect a short bare wire from J2 (S) to J3 (S).

( ) Connect a wire from A2 (S) to B7 (S).

( ) Twist the leads from the filter choke together and pass them through the grommet G. Run these leads close to the back edge of the chassis over to the socket C.

( ) Connect one lead of the choke to C8 (NS).

( ) Connect the other lead to C3 (NS).

Note: In wiring the following condensers, cut the leads to a length that will allow the condensers to fit snugly between their connection points. See Pictorial 1.

( ) Connect the positive lead of an 8 μfd 350 volt condenser to C8 (S). The positive lead will have the word POSITIVE or PLUS markings on that end of the condenser case. Connect the other lead of this condenser to TD2 (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to TD2 (S).

( ) Connect the other lead of this condenser to the solder lug near the chassis edge (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to C3 (NS).

( ) Connect the other lead of this condenser to TD1 (NS).

( ) Connect the positive lead of an 8 μfd 350 volt condenser to TD1 (NS).

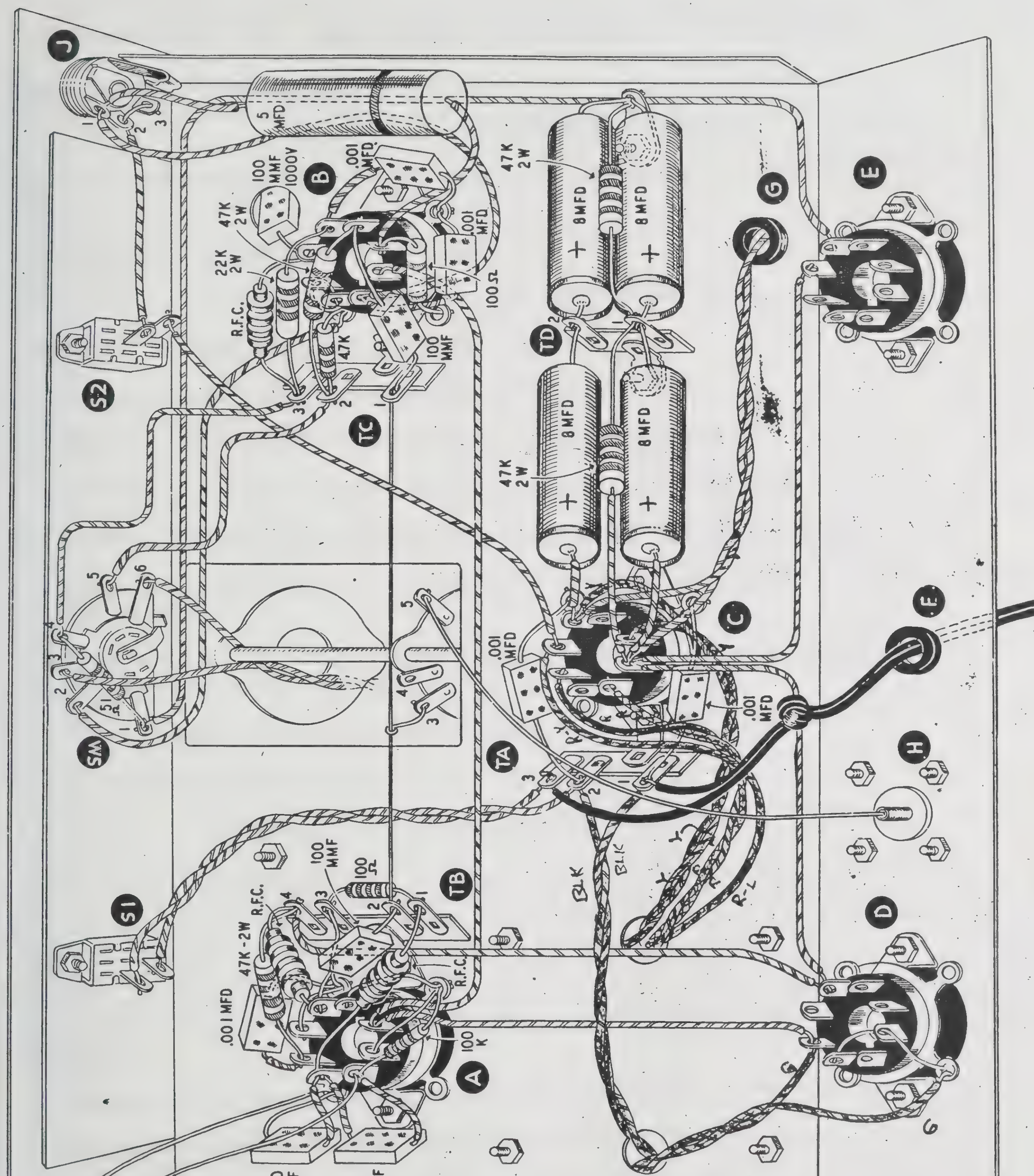
( ) Connect the other lead of this condenser to the solder lug near the chassis edge (NS).

( ) Connect a 47 KΩ 2 watt resistor between C3 (NS) and TD1 (NS).

( ) Connect a 47 KΩ 2 watt resistor between TD1 (S) and the solder lug at the edge of the chassis (S).

( ) Connect a wire from C3 (NS) to D4 (NS).

( ) Connect a wire from C3 (S) to E3 (S).



J
5 MFD
.001 MFD
100 MMF 1000V
B
47K 2W
22K 2W
.001 MFD
100Ω
R.F.C.
47K
100 MMF
S2
TC
TD
8 MFD
8 MFD
47K 2W
8 MFD
8 MFD
47K 2W
G
E
SW
TA
.001 MFD
C
.001 MFD
F
H
S1
TB
R.F.C.
47K-2W
100 MMF
100 Ω
R.F.C.
.001 MFD
100 K
A
D
100 MMF
15 MMF
X
BLK
R-L

PICTORIAL 1

( ) Connect one end of a wire about 16" long to E4 (S).

( ) Run the wire around the outside edge of the chassis as shown in Pictorial 1 and connect the other end to SM1 (NS). Refer to Figure 1 or Pictorial 1 for SM1 connection.

This completes the power supply wiring.

WIRING OF THE OSCILLATOR TUBE

Note: For best operation and ease of construction, parts should be placed as shown in Pictorial 1.

( ) Connect a wire from D4 (S) to TB4 (NS).

( ) Connect a piece of light bare wire to A3 (S). Pass the wire through AG1 (NS) to A1 (S).

(✓) Connect a 100 KΩ resistor from A4 (NS) to AG1 (S).

( ) Connect a piece of light bare wire from A7 (S) to AG4 (NS).

CAUTION: Do not use 6 1/2" length of heavy bus wire until called for.

( ) Connect a heavy bare wire from X1 (S) to AG3 (NS). See Pictorial 1.

(✓) Connect a .001 μfd mica condenser from A6 (use sleeving) (NS) to AG4 (NS).

(✓) Connect one end of a 100 μμf mica condenser to AG3 (S). Connect the other end to A5 (NS). (Use sleeving.)

( ) Connect one end of a 15 μμf mica condenser to A5 (NS). (Use sleeving.) Connect the other end to A4 (NS). (Use sleeving.)

(✓) Connect a heavy bare wire from X2 (S) to A4 (S). See Pictorial 1.

( ) Connect an RF choke from A5 (S) to TB1 (NS).

( ) Connect a 100 Ω 1/2 watt resistor from TB1 (S) to TB3 (NS).

Note: At this point, the builder has two choices in the method of keying the transmitter. In the interest of stability, it is recommended that only the amplifier stage be keyed. However, it may be wired so that both the amplifier and oscillator stage can be keyed simultaneously for break-in operation. If it is desired to key only the amplifier, connect a short bare wire from TB3 (S) to AG4 (S). If both stages are to be keyed, connect a .001 μfd condenser from TB3 (NS) to AG4 (S) in place of the bare wire; then, connect a wire to TB3 (S). Run this wire along the front edge of the chassis to J1 (NS). All wiring instructions that follow apply for either method of keying.

(✓) Connect a 47 KΩ 2 watt resistor from A6 (S) to TB4 (NS).

( ) Connect the single pi 90 μh RF choke from A8 (NS) to TB4 (S).

(✓) Connect a 100 μμf mica condenser from A8 (S) to TB2 (NS).

This completes the oscillator tube wiring.

AMPLIFIER TUBE WIRING

( ) Connect a light bare wire from B1 (S). Pass the wire through B2 (S) to BG1 (NS).

( ) Connect a 4.7 KΩ resistor from TC2 (NS) to BG1 (NS).

( ) Connect a .001 μfd mica condenser from BG3 (NS) to B4 (NS). (Use sleeving.)

( ) Connect a .001 μfd mica condenser from BG3 (S) to B8 (NS). (Use sleeving.)

( ) Connect a wire from B8 (S) to J1 (NS).

(√) Connect the outside foil of a .5 μfd paper condenser to B6 (NS). (Use sleeving.) See Pictorial 1 for mounting position.

( ) Connect the other end of the condenser to J1 (S). (Use sleeving.)

( ) Connect a 100 Ω 1 watt resistor from B6 (S) to BG4 (S).

( ) Connect a 100 μμf mica condenser from TC1 (NS) to B5 (NS).

( ) Connect a 47 KΩ 2 watt resistor from B5 (S) to TC2 (NS).

( ) Connect a wire from TC2 (S) to SM5 (S).

( ) Connect a wire from SM2 (S) to BG1 (S). Run the wire along the front of the chassis.

( ) Connect a 22 KΩ 2 watt resistor from B4 (S) to TC3 (NS).

( ) Connect a 100 μμf 1,000 volt mica condenser to B3 (NS). Pass this condenser through the hole in the chassis adjacent to the tube socket so that the insulated part of the condenser is centered in the hole. Leave the other end free. See Pictorial 1.

( ) Connect an RF choke between B3 (S) and TC3 (NS).

( ) Connect a wire from TC3 (S) to SM4 (NS).

( ) Connect a 51 Ω 1 watt 5% resistor from SM1 (S) to SM4 (S).

This completes the amplifier wiring.

COIL ASSEMBLY AND WIRING

( ) Mount the oscillator coil as shown in Figure 2 placing a solder lug under the head of the screw. Use a lockwasher and nut on the underside of the chassis.

( ) Mount the oscillator and amplifier variable tuning condensers CO and CA on the panel as shown in Figure 2, using ~~round head 6-32 screws~~. a control lockwasher behind the panel and a control flatwasher and nut on the front. see fig 3 for parts. [illegible]

( ) Examine Pictorial 2 carefully, noting the terminal positions of the band switch SB and mount on the panel as shown in Pictorial 2 omitting the lockwasher. Use a flatwasher and nut on the front of the panel and do not tighten the nut yet.

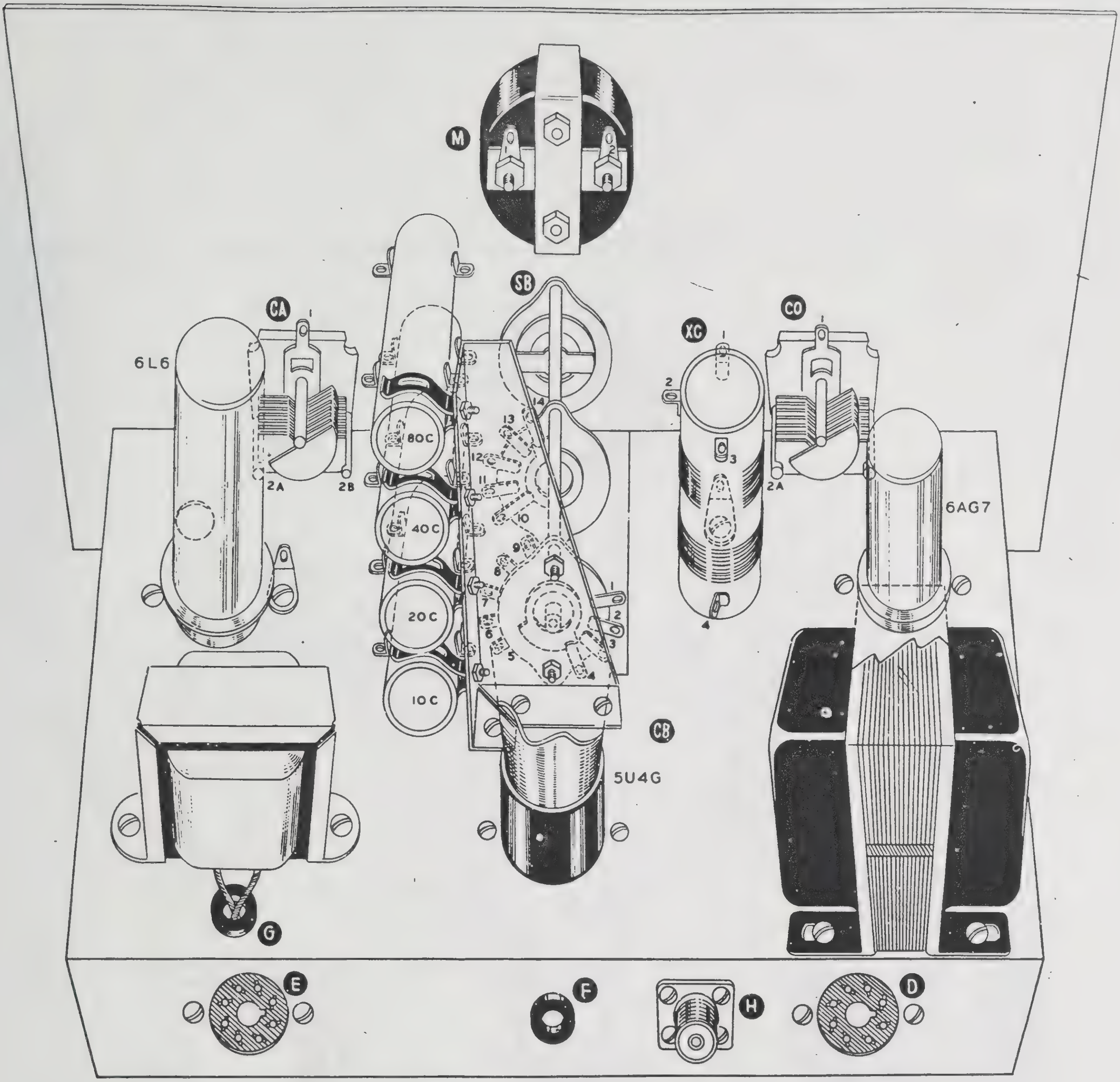


Fig. 2

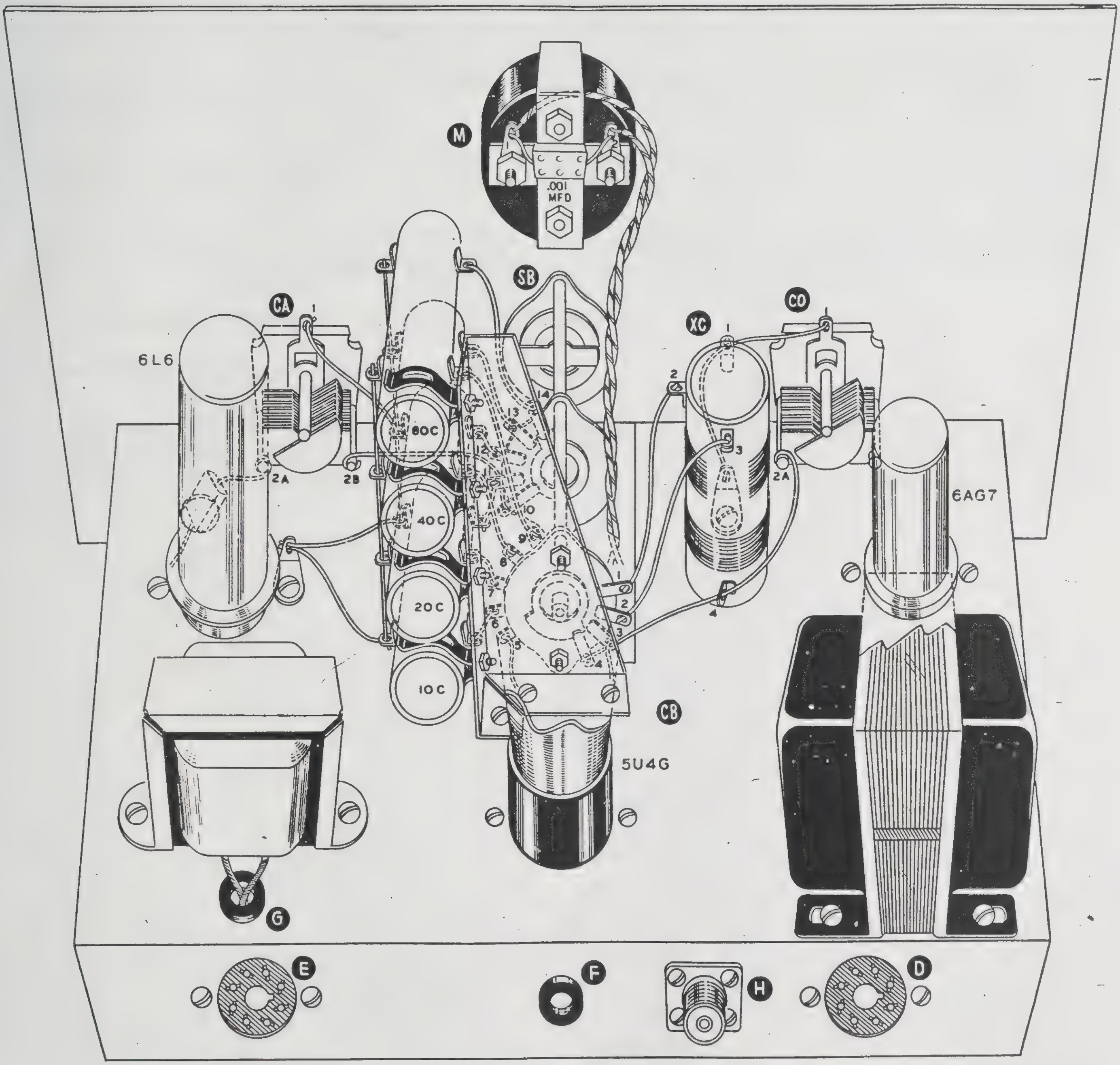
( ) By referring to Figure 2 and Pictorial 2, you will note that the coil bracket CB anchors the rear end of the band switch as well as supporting the amplifier coils. Slide the holes in the flat portion of the coil bracket over the two screws protruding from the rear of the band switch and secure using 5-40 nuts and lockwashers furnished.

( ) Now align the three holes in the base of the coil bracket with the holes in the chassis and mount the coil bracket to the chassis using 6-32 screws, nuts, and lockwashers.

( ) Tighten the 3/8" band switch nut.

( ) Mount the four coil clamps on the coil bracket as shown in Figure 2.

( ) Mount the meter through the large hole at the top of the panel and secure the meter to the panel by means of the clamp furnished. Be sure to align the meter square with the panel before tightening the clamp.


M
.001
MFD
SB
CA
CO
XC
6L6
6AG7
2A
2B
2A
80C
40C
20C
10C
CB
5U4G
G
E
F
H
D

PICTORIAL 2

COIL WIRING

Note: The wiring of the oscillator and amplifier coils is somewhat difficult due to the large size wire used. The work may be performed from both the top of the chassis and through the large hole from the bottom. Care taken at this point will result in neatness and operating efficiency.

( ) Connect a wire from SM3 (S) to + meter M1 (NS).

( ) Connect a wire from SM6 (S) to - meter M2 (NS).

( ) Connect a .001 μfd mica condenser from M1 (S) to M2 (S).

( ) Connect a heavy tinned wire from CO1 on the oscillator tuning condenser (S) to XC1 on the oscillator coil (NS).

( ) Connect a heavy tinned wire from XC1 (S) on the oscillator coil to the solder lug under the coil mounting screw (S).

( ) Run a heavy tinned wire from SB4 on the band switch (S) through terminal XC4 on the oscillator coil to terminal CO2A on the tuning condenser. Solder XC4 and CO2A.

( ) Connect a heavy tinned wire from SB2 (S) to XC3 (S).

( ) Connect a heavy tinned wire from SB1 (S) to XC2 (S).

Note: The amplifier coils may be identified by the number of turns on each. The 10 meter coil 10C having the least turns, and the 80 meter coil 80C having the most. The coils 20C, 40C, and 80C have condensers connected across the terminals 1 and 2. See Figure 5 for mounting details.

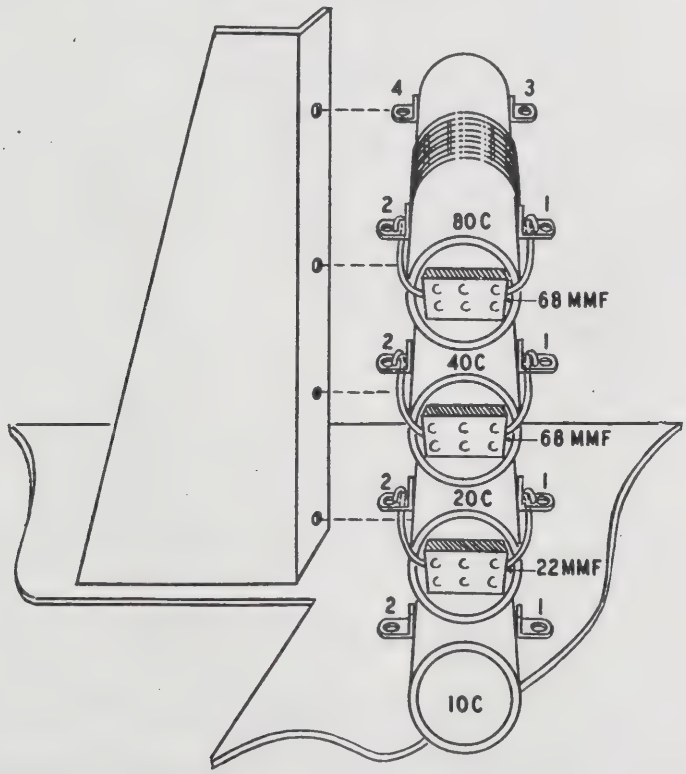


Fig. 5

( ) Connect a 22 $\mu\mu$f 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 20C (NS).

( ) Connect a 68 $\mu\mu f$ 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 40C (NS).

( ) Connect a 68 $\mu\mu f$ 2% 1,000 volt silver mica condenser across terminals 1 and 2 of coil 80C (NS).

( ) Insert the 10 meter coil 10C in the lowest coil clamp. Connect a heavy tinned wire from 10C2 to SB11. Align the coil straight and parallel to the chassis; then solder the connections.

( ) Connect a short heavy tinned wire from 10C4 (S) to SB6 (S).

( ) Insert the 20 meter coil 20C in the next higher coil clamp.

( ) Connect a short heavy tinned wire from 20C2 to SB12. Observe the same precautions as with the 10 meter coil and solder the connections.

( ) Connect a short heavy tinned wire from 20C4 (S) to SB7 (S).

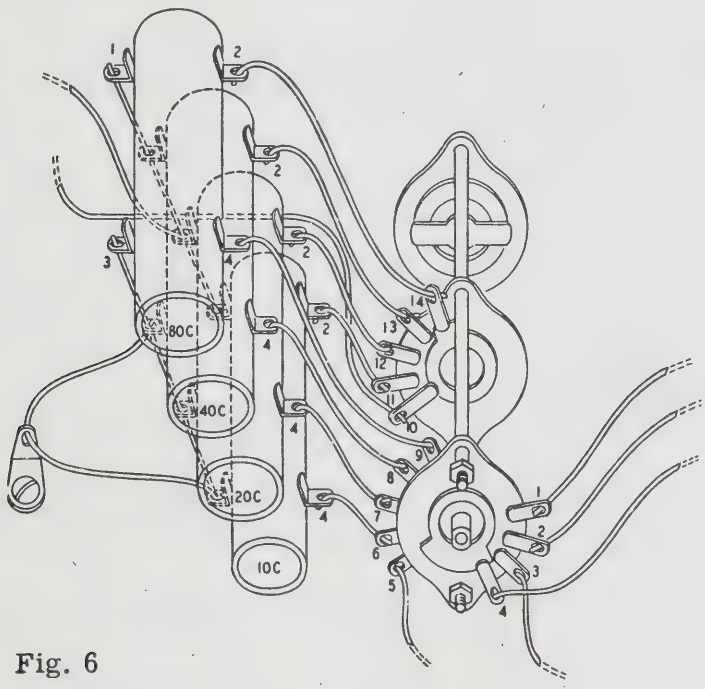


Fig. 6

( ) Insert the 40 meter coil 40C in the next coil clamp.

( ) Connect a short heavy tinned wire from 40C2 to SB13. Align the coil and solder the connections.

( ) Connect a short heavy tinned wire from 40C4 (S) to SB8 (S).

( ) Insert the 80 meter coil 80C in the top coil clamp.

( ) Connect a short heavy tinned wire from 80C2 to SB14. Align and solder.

( ) Connect a short heavy tinned wire from 80C4 (S) to SB9 (S).

( ) Run a heavy tinned wire through the #1 terminals of all the coil. See Pictorial 2 and Figure 6.

( ) Solder connections 80C1 and 40C1.

( ) Connect one end of a heavy tinned wire to SB10 (S). Run this wire around coil 10C to CA2B on the tuning condenser (S). See Figure 6.

( ) Connect the end of the 100 $\mu\mu$f condenser coming through the chassis to CA2A (S).

( ) Run a heavy tinned wire from CA1 on the amplifier tuning condenser to 20C1. Solder CA1 and 20C1.

( ) Run a heavy tinned wire through all the #3 terminals on the coils. Solder all connections but 10C3.

( ) Run a heavy tinned wire from 10C1 through the solder lug adjacent to the tube socket to 10C3. Solder all connections.

( ) On the bottom side of the chassis run the 6 1/2" length of bus between TB2 (S) and TC1 (S).

( ) Connect a heavy tinned wire to SB3 (S). Run this wire clear of terminal SB4 to the bus wire just installed. Make a firm connection to this bus and solder.

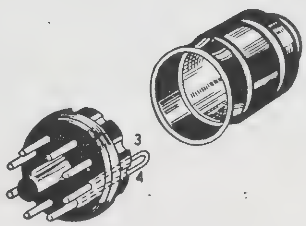
( ) Run a heavy tinned wire from SB5 down through the large hole in the chassis to the center terminal of the coax jack H. Arrange wire to clear all components and solder the connections. See Pictorial 1.

( ) Insert the AC line cord through the grommet F in the rear of the chassis. Tie a knot in the cord about 3" from the end.

( ) Connect one end of the cord to TA1 (S).

( ) Connect the other end to TA3 (S).

Fig. 7



( ) On the male octal plug furnished, connect a jumper from pin 3 to pin 4 (S). See Figure 7.

( ) Install the two round knobs on the tuning condensers. Align the pointers in such a manner that the pointer reads 100 when the condenser is fully meshed (maximum capacity).

( ) Install the pointer knobs on the band and meter switch. Tighten the set screw on the flat part of the switch shaft.

This completes the wiring of your Heathkit Model AT-1.

TRANSMITTER

TESTING THE TRANSMITTER

CAUTION: VOLTAGES DANGEROUS TO LIFE ARE PRESENT ON THIS TRANSMITTER. USE EXTREME CARE WHEN TRANSMITTER IS OUT OF CASE.

Before testing the transmitter, recheck all wiring. Damage to components may result due to errors in wiring.

( ) Insert an 80 meter crystal in the crystal socket.

( ) Plug a key into the key jack.

( ) Turn the STANDBY switch off and the OFF-ON switch on. Allow about two minutes for warmup.

( ) Turn the band switch to the 80M position and the meter switch to GRID position.

( ) Turn the STANDBY switch to PLATE-ON position and depress the key momentarily. The meter should indicate a low value of current. Release key.

( ) Turn the meter switch to the PLATE position and again depress the key. The meter should read a high value of current. Quickly tune the control marked OUTPUT. The meter should show a pronounced dip. Release key.

( ) Turn the band switch to the 40M position and the meter switch to the GRID position.

( ) Depress the key and tune the DRIVER control for maximum indication on the meter. Release key.

( ) Turn meter switch to the PLATE position and depress key. Tune the OUTPUT control for a pronounced dip. Release key.

( ) Repeat the last two steps on the 20 and 10 meter bands. If the results obtained are similar to those described above, the transmitter is operating correctly and may be installed in the cabinet. If not, refer to the section on trouble-shooting in the back part of this manual.

( ) Install the rubber feet on the cabinet. See Figure 8.

( ) Slide the transmitter into the cabinet being careful not to damage any of the components.

( ) Attach the transmitter to the cabinet by means of the two sheet metal screws in the rear and the eight sheet metal screws in the panel.

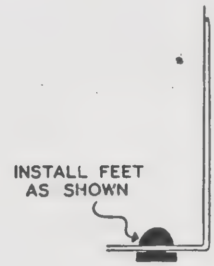


Fig. 8

This completes the transmitter.

COUPLING THE TRANSMITTER TO THE ANTENNA

Almost any piece of wire may be made to radiate when a source of RF power is connected to it. However, this does not mean it will radiate well and if an antenna is constructed based on this supposition, it is quite likely you will not get out of your backyard.

The results obtained with any transmitter are more dependent upon the antenna and the coupling system than upon the power input to the transmitter. Consequently, the effort applied to the design and installation of an efficient antenna system and the care taken in matching this system to the transmitter will be well worth the time and trouble taken.

It is not within the scope of this manual to go into a complete description of all types of antennas and coupling systems. Therefore, we will describe only a few basic types of antennas and coupling systems. For more detailed descriptions of antenna systems, the reader is referred to the handbooks published by amateur radio organizations.

END FED-HERTZ AND MARCONI

This consists merely of a single wire from 1/4 wave length long to any even multiple thereof. One end of the wire is coupled to the transmitter and the other end supported as free in space as possible. If this antenna is operated against ground, it is known as a MARCONI antenna. Its greatest disadvantage is due to the necessity of bringing part of the radiating element into the radio room where its proximity to nearby objects increases losses. Its greatest advantage is its simplicity and compact size where space is at a premium. See Figures 9 and 10.

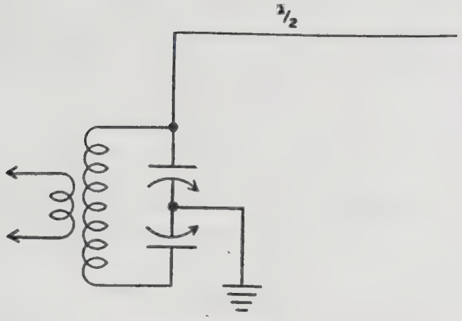


Fig. 9

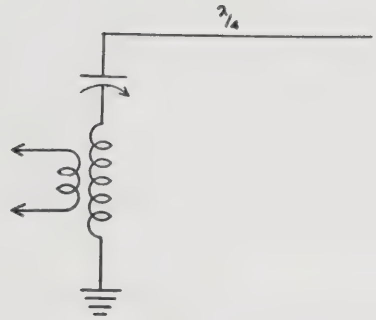


Fig. 10

In Figure 9 the coil and condenser combination should be capable of tuning to the transmitter output frequency. In Figure 10 the condenser should have a large capacity and the coil tapped to allow for any length of antenna.

END FED-ZEPP, DIPOLE, AND FOLDED DIPOLE ANTENNAS

In the average station, it will be found expedient to have the radiating portion of the antenna some distance from the transmitter. This statement assumes that the amateur will have his antenna up high and clear of nearby objects, whereas, the actual transmitter may be in the basement or any other room in the house. In this case, some form of transmission line must be used to efficiently connect the transmitter to the antenna.

There are two basic types of transmission lines; the untuned, non-resonant, or "flat" line, and the tuned, resonant line. The untuned line may be made any length within reason providing it meets all requirements of a non-resonant line. These requirements are quite critical. The untuned line must be physically symetrical throughout its length and must be terminated in its characteristic impedance. In general, it is a one band antenna as the terminating impedance of the antenna will not remain the same for operation on other bands. The untuned line has a standing wave ratio (SWR) of 1 to 1. More will be said about standing waves later.

The resonant or tuned transmission line is the type more generally used when it is desired to operate an antenna on several harmonically related bands. In this type of transmission line, standing waves are usually always present to some degree. They should be kept to a minimum.

STANDING WAVES: When energy is applied to one end of a transmission line, it flows out along the line from the source to the terminating point. In this case, the antenna. If the impedance of the terminating point exactly matches the surge impedance of the line, the energy is absorbed as fast as it arrives at that point. If the terminating point does not match the impedance of the line, some of the energy is reflected back along the line. The ratio of energy going out along the line to the amount reflected back along the line represents the standing wave ratio (SWR).

This, in turn, is equal to the ratio of mismatch between the line and its terminating point.

TRANSMISSION LINE SURGE IMPEDANCE:

$$Z_S = 276 \text{ LOG}_{10} \frac{2S}{D}$$

S being the center to center spacing and D the diameter of the conductors measured in the same units.

This formula is for two-wire transmission lines. If coax cable is used for transmission line, the impedance is governed by the type used. This impedance being fixed in the manufacturing process. The impedance of an unknown coax line may be calculated from the following formula.

COAX IMPEDANCE:

$$Z_0 = 138 \text{ LOG}_{10} \frac{D_1}{D}$$

D_1 being the inside diameter of the outer conductor. D the outside diameter of the inter-conductor measured in the same units.

The antenna systems mentioned at the beginning of this section all use some form of transmission line, either coax or two-wire line can be used on any of them but may not be as well suited to one as to the other.

The Zepp antenna, which is an End Fed type capable of multi-band operation, is usually used with the two-wire tuned line. It has been the "hams" old standby for many years and is ideally suited where one end of the antenna is in the vicinity of the transmitter. It is tuned either in series or parallel depending upon the electrical length of the transmission line. The Zepp antenna may be coupled to the transmitter as shown in Figure 11.

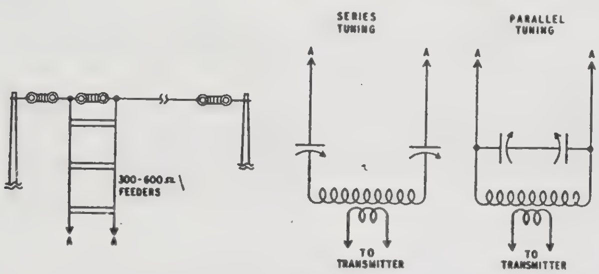


Fig. 11

The dipole, sometimes incorrectly called a Center Fed Zepp, consists of two quarter wave elements with the transmission line connected at the electrical center. The characteristic impedance of this type antenna is approximately 72 ohms and, as such may be used with 72 ohm coax to form a non-resonant line providing the electrical length of the antenna proper is exactly matched to the frequency operated.

As previously stated, this form of transmission line tends to limit the antenna to one-band operation. Consequently, the center fed antenna is usually fed with a two-wire resonant system and is tuned in the same manner as shown in Figure 11 for the end fed Zepp antenna.

The folded dipole antenna is ideally suited to flat line operation and although this again presents the single band characteristic, it probably represents the easiest method for the beginning amateur to get on the air. The characteristic impedance of the folded dipole is approximately 300 ohms, which just happens to be the surge impedance of the "twin-lead" used in TV work. Thus, by using "twin-lead" for the flat top part of the antenna and more of the same for the transmission line, we have our antenna ready to radiate. The method of doing this is illustrated in Figure 12.

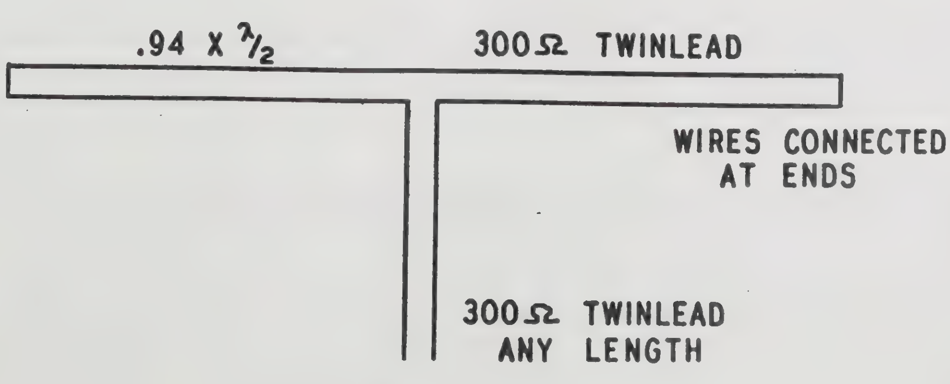


Fig. 12

The two wires of the "twin-lead" are shorted at the ends, and one of the wires is opened at the center to form the flat top. Another piece of "twin-lead" is connected to the open center wires to form the transmission line. It is recommended that transmitting type "twin-lead" be used. Antennas of this type are available commercially.

ANTENNA FORMULA

One Wave Length in Space = $\frac{300,000}{F_{kc}}$ Meters

Center Fed Dipole One Half Wave Long - Length in feet = $\frac{468}{F_{mc}}$

Folded Dipole One Half Wave Long - Length in feet = $\frac{462}{F_{mc}}$

Zepp Antenna One Half Wave Long - Length in feet = $\frac{492}{F_{mc}}$

ANTENNA COUPLER

The antenna coupler must meet one main requirement. It must match the transmission line to the output of the transmitter. It must also serve as a method of variable coupling between the antenna and the RF amplifier, if this has not been taken care of in the transmitter. It helps to eliminate TVI by the suppression of harmonics.

Basically, the antenna coupler is an impedance transformer, transforming the relatively high impedance output of the transmitter to the low impedance of the transmission line. The additional tuned circuit it incorporates tends to suppress harmonics present in the transmitter output. It may be placed some distance from the transmitter for convenience of connecting to the transmission line, providing coaxial cable is used to couple it to the transmitter. The AT-1 is equipped for coaxial coupling to the antenna coupler. See Figure 13 for details.

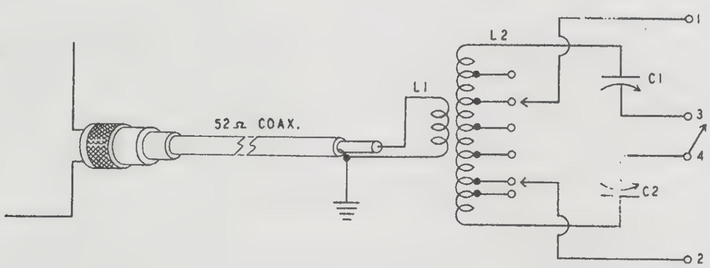


Fig. 13

The coil L1 should match the impedance of the coax cable as closely as possible at the frequency operated and the spacing between it and L2 should be adjustable to control the antenna loading.

The circuit consisting of L2, C1, and C2 must be capable of tuning to the transmitter frequency. If it is desired to series tune the antenna, the shorting bar between 3 and 4 is opened and the transmission line connected at these points. For parallel tuning, 3 is shorted to 4 and the transmission line connected to 1 and 2. Taps are provided on the coil L2 to facilitate matching the transmission line.

NOTE: For more complete information about antennas and coupling systems, refer to the amateur handbook.

AT-1 OPERATION ADJUSTMENTS

The AT-1 transmitter may be operated on the amateur bands of 80, 40, 20, 15, 11, and 10 meters using crystal or VFO control. Before attempting operation in any particular band, the operator should ascertain the frequency range of the desired band and the type of emission permissible in any portion of that band. After the desired frequency of operation has been arrived at, the crystal frequency necessary may be found by dividing the desired frequency by the harmonic relation to the crystal fundamental.

It is possible to operate the 10 meter band from an 80 meter crystal operating on its 8th harmonic but it is advisable to use 40 meter crystals for operation in the bands from 20 to 10 meters.

A VFO may be used to control the transmitter by plugging the output of the VFO into the crystal socket. If a VFO is used, care should be taken to ascertain that the VFO output is within the band, particularly on the higher frequencies where the error will be multiplied.

80 METER OPERATION

NOTE: All adjustments should be made quickly as the tubes draw excessive current when their associated circuits are not in resonance.

It is assumed that the proper antenna and coupler is attached to the transmitter in the following paragraphs and that a key is plugged in.

Plug in a crystal with a frequency between 3,500 and 4,000 kc. Turn on power switch and allow transmitter to warm up for a short time. Leave STANDBY switch in STANDBY position. Turn the meter switch to the PLATE position. Turn on STANDBY switch, depress key and quickly tune OUTPUT control for a dip. It is not necessary to adjust the DRIVER control on this band.

While holding key depressed, tune antenna coupler for a rise in plate current. As the antenna is tuned for increased current, continuously adjust OUTPUT control for resonance as indicated by a dip in current. A point should be reached where the meter will still show a dip when tuned through resonance, but at a considerably increased current.

The final current reading with the antenna and transmitter both tuned to resonance should be about 60 to 80 milliamperes. If it is much lower than this, the antenna coupling should be increased. If a point is reached where it is no longer possible to dip the plate current, the antenna is over-coupled and the coupling should be reduced.

40 METER OPERATION

Plug in a crystal in the frequency range between 3,500 and 3,650 kc and turn meter switch to GRID position. Turn STANDBY switch to on, depress key and quickly tune DRIVER control for maximum meter reading. Release key. Turn meter switch to PLATE position, depress key and tune for dip. Tune antenna as outlined under 80 meter operation.

20, 15, 11 AND 10 METER OPERATION

The method of tuning for these bands is exactly the same method as for the 40 meter band, except for the choice of crystal frequencies. The 15 meter and 11 meter bands are operated on the 10 meter position of the band switch. Below is a chart of crystal frequencies necessary for operation in any of the amateur bands.

WARNING: The frequencies listed cover the entire band limits. It is not advisable to operate near the band edge. When operating in the 15 meter band with a crystal frequency near 5250 kc, it is possible to tune to the 6th harmonic. As the 6th harmonic of that crystal is outside of any of the amateur bands it should be avoided. In any case, where two dips are noted when tuning the OUTPUT control, the one giving the most pronounced dip is the correct tuning.

80 METERS	40 METERS	20 METERS
3700 - 3750	7150 - 7200	
3500 to 4000 kc	7000 to 7300 kc	14000 to 14350
Crystal	Crystal	Crystal
3500 to 4000 kc	3500 to 3650 kc	3500 to 3587.5 kc 7000 to 7175 kc

15 METERS	11 METERS	10 METERS
21100 - 21250		
21000 to 21450 kc	26960 to 27230 kc	28000 to 29700 kc
Crystal	Crystal	Crystal
5250 to 5362.5 kc	6740 to 6807.5 kc	3500 to 3712.5 kc 7000 to 7425 kc 14000 to 14850 kc

Crystals operating between any of the figures listed above can be used for operating the AT-1 in the band they are listed under.

RADIO TELEPHONE OPERATION

NOTE: Phone operation is limited to certain parts of the amateur bands only. It is also restricted to certain grades of amateur licenses. This must be taken into consideration before operating the AT-1 as a phone transmitter.

Modulation of a transmitter involves several factors not present in CW operation. For example, the load presented by the radio frequency amplifier must match the output impedance of the modulator. The modulator must have an impedance matching device, such as a transformer with the proper ratio to match the load resistance of the modulator tubes to the radio frequency load. The modulator must be capable of an audio output equal to 1/2 the power input to the radio frequency amplifier for 100% modulation. Some form of microphone and speech amplifier is necessary and the modulator for amateur use should reject audio frequencies above 3,000 cycles per second.

Frequencies above 3 kc are not necessary for the transmission of intelligent speech. Therefore, any frequencies above this figure not only waste usuable power but cause interference to other stations by increasing the band width of the transmitted signal.

MODULATOR DESIGN

The method of calculating the load impedance presented by the radio frequency amplifier when plate modulated is given by the formula:

$$Z_m = \frac{E_b \times 1000}{I_p}$$

where E_b is the amplifier plate voltage and I_p is the amplifier plate current in milliamperes. In the case of a screen grid tube, such as the 6L6 used in the AT-1, both plate and screen are modulated, so I_p used in the formula represents the total current for both plate and screen grid. EXAMPLE: AT-1 transmitter operating with 400 volts on the plate and 80 MA total plate and screen grid current:

$$Z_m = \frac{400 \times 1000}{80} = 5000\ \Omega \text{ Load Impedance}$$

Power input to the amplifier is expressed by the formula:

$$\text{Power In Watts} - E_b I_p$$

E_b is the amplifier plate voltage and I_p is the amplifier plate current in amperes.

As we require half the audio power output that we have RF power input, the audio requirements under the operating conditions stated above will be:

$$\text{Audio output in watts} - .5 \times 400 \times .080 \text{ or } 16 \text{ watts}$$

From the tube table it is found that push-pull 6L6's operating class AB_1 with 250 plate volts will give an output of 18 watts. The plate to plate load resistance of the tubes is found to be 5,000 ohms. Therefore, an output transformer having a 5,000 ohm primary and a ratio of total primary to secondary turns of 1 to 1 will match the modulator to the transmitter.

NOTE: This example only applies to one set of conditions, a change in the antenna loading will cause a change in RF amplifier plate current with a subsequent change in load impedance and wattage input. A different choice of modulator tubes would affect the output transformer necessary. However, from the formula given above, the modulator for any set of operating conditions may be calculated.

The reader is again referred to the amateur radio handbooks for more detailed information on the subject of phone operation.

MODULATION CONNECTIONS TO THE AT-1

In order to modulate the AT-1 transmitter, it is merely necessary to remove the jumper from pins 3 and 4 on the male octal plug, and connect the proper impedance output from the modulator transformer across these two pins. As the output of the modulator is AC, either terminal of the modulation transformer may be connected to either pin on the octal plug.

As the output impedance of the modulation transformer is more or less fixed, it is usually customary to adjust the transmitter by loading the antenna to a lesser or greater degree in order to present the proper RF load impedance to match the modulator.

VFO OPERATION

When using a VFO with the AT-1, it will be necessary to short out the cathode of the RF choke and resistor on the 6AG7. If a wire is connected from A5 to D6, an octal plug having a jumper between pins 6 and 7 may be inserted in socket D for VFO operation. If the VFO receives its power from the AT-1, its plug can be wired in the same manner.

IN CASE OF DIFFICULTY

The greatest single cause of trouble is due to wiring mistakes. First, check very carefully the transmitter wiring. Due to the large amount of bare wire used in this kit, there is a good chance that a short circuit will occur. All bare wire should be kept away from the chassis and other components.

The meter may be used to some degree in trouble shooting. In the GRID position, it indicates whether the oscillator is operating correctly and, in the PLATE position, it does the same for the amplifier stage. No deflection of the meter in either position usually indicates the trouble is in the power supply.

A voltage chart is often a good means of locating trouble. The chart below gives the voltages to be expected under normal operating conditions. All readings are DC, except where indicated. These voltages were measured with an 11 megohm input vacuum tube voltmeter. A normal variation of ±15% is to be expected. With regular voltmeters, reading may be somewhat lower.

SOCKET VOLTAGE CHART

TUBE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
5U4G	0	450	440	430AC	0	430AC	0	450
6AG7	0	6.3AC	0	-95	3.5	220	0	430
6L6	0	0	420	250	-45	0	6.3AC	0

The trouble shooting chart included at this point may also be used to good advantage in case difficulty occurs.

TROUBLE	SYMPTOMS	POSSIBLE CAUSE
Transmitter inoperative	Meter reads high current in PLATE position. No indication in GRID position.	Oscillator not oscillating due to: 1. Defective or dirty crystal. 2. Defective 6AG7 tube. 3. No voltage on oscillator plate or screen grid. (Pins 6 and 8 on voltage chart.) 4. Shorted or open circuit on oscillator coil or terminals SB1 through 4 on the band switch. 5. DRIVER control not tuned properly.
Transmitter inoperative	Meter reads in GRID position. Does not read in PLATE position.	Amplifier not drawing current due to: 1. Modulator plug not inserted in socket. 2. Modulator plug does not have jumper between terminals 3 and 4. 3. Defective 6L6 tube. 4. No voltage on plate and screen grids. (Pins 3 and 4 on the voltage chart.) 5. Cathode circuit to ground open. (Check key jack.) 6. Plate voltage supply open at meter switch. (Terminals 1 and 4 on meter switch.)
Transmitter inoperative	Meter reads in both GRID and PLATE positions. OUTPUT tuning will not dip meter current.	Amplifier will not resonate due to: 1. 100 $\mu\mu f$ 1,000 volt condenser circuit open between B3 and CO2A. 2. "Tank" circuit open between CA2B and SB10. 3. Amplifier coil connections shorted. 4. Switch positions SB10 through 14 open or shorted. 5. Antenna overcoupled.
Transmitter inoperative	Meter does not read in either position.	No voltages on tubes due to: 1. Open circuit at switches S1 or S2. 2. Defective 5U4G tube. 3. Short in high voltage circuit. 4. Open circuit at SM3 or 6 on the meter switch.

Transmitter will not load when connected to an antenna.	No increase in plate current with antenna connected.	1. Short or open connections on #4 amplifier coil terminals. 2. Shorted or open connections on terminals SB5 through 9 on the band switch. 3. Antenna coupler not tuned to band being operated. 4. Inefficient antenna.

TELEVISION INTERFERENCE (TVI)

There is no single method of combating television interference that will apply to all circumstances. Each individual installation may require a different technique. However, a few hints are included here covering the usual methods of eliminating TVI.

LOW-PASS FILTER

A low-pass filter inserted in the coaxial line between the transmitter and the antenna coupler is very effective. The low-pass filter will eliminate any harmonic radiation above its cutoff frequency, usually 40 to 50 mc. The figure below describes one method of making a low-pass filter.

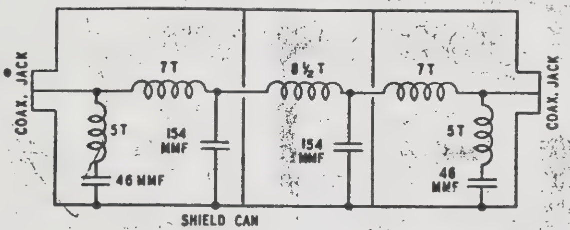


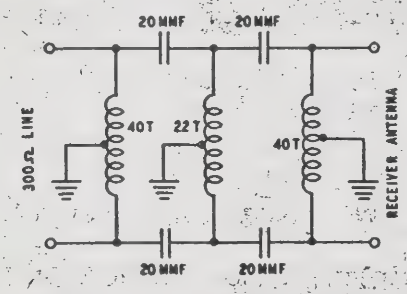
Fig. 14

Coils are wound of No. 12 or 14 wire 1/2" inside diameter, spacing 8 turns per inch.

HIGH-PASS FILTER

The high-pass filter is used where only one or two television sets are affected out of many. It must be inserted in the TV lead-in directly at the antenna terminals of the receiver. The figure below describes one method of making a high-pass filter.

Fig. 15



Coils are wound of No. 30 wire on a 1/8" diameter form.

AC LINE FILTER

It is sometimes possible that the transmitter is feeding energy from the antenna into the house wiring. This energy in turn is fed directly into the receiver through its line cord. The figure below shows a method of constructing an AC line filter for the receiver.

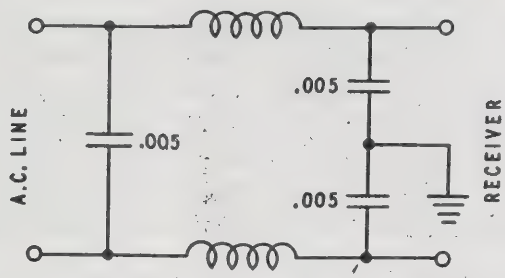


Fig. 16

The coils consist of a 2" length of close wound No. 18 wire on 1/2" diameter form.

There are numerous other methods which will help to eliminate TVI. In general, the transmitting antenna should be kept away from receiving antennas. All RF components should be shielded. Consequently, the AT-1 should be operated in the case at all times.

For further information on television and broadcast interference elimination, refer to the amateur handbooks.

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $5.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the specified performance level in your instrument. Factory repair service is available for a period of one year from the date of purchase or you may contact the Engineering Consultation Department by mail. For information regarding the possible modification of existing kits, the volumes listed in the Bibliography section are recommended. They can be obtained at or through your local library, as well as at any electronic outlet store. Although the Heath Company sincerely welcomes all comments and suggestions, it would be impossible to design, test, evaluate and assume responsibility for proposed circuit changes for specific purposes. Therefore, such modifications must be made at the discration of the kit builder according to information which will be much more readily available from some local source.

SHIPPING INSTRUCTIONS

Before returning a unit for service, be sure that all parts are securely mounted. Attach a tag to the instrument giving name, address and trouble experienced. Pack in a rugged container, preferably wood, using at least three inches of shredded newspaper or excelsior on all sides. DO NOT SHIP IN THE ORIGINAL KIT CARTON AS THIS CARTON IS NOT CONSIDERED ADEQUATE FOR SAFE SHIPMENT OF THE COMPLETED INSTRUMENT. Ship by prepaid express if possible. Return shipment will be made by express collect. Note that a carrier cannot be held liable for damage in transit if packing, in HIS OPINION, is insufficient.

SPECIFICATIONS

All prices are subject to change without notice. The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

WARRANTY

The Heath Company limits its warranty of parts supplied with any kit to a period of three (3) months from the date of purchase. Replacement will be made only when said part is returned postpaid, with prior permission and in the judgment of the Heath Company was defective at the time of sale. This warranty does not extend to any Heathkits which have been subjected to misuse, neglect, accident and improper installation or applications. Material supplied with a kit shall not be considered as defective, even though not in exact accordance with specifications, if it substantially fulfills performance requirements. This warranty is not transferable and applies only to the original purchaser. This warranty is in lieu of all other warranties and the Heath Company neither assumes nor authorizes any other person to assume for them any other liability in connection with the sale of Heathkits.

The assembler is urged to follow the instructions exactly as provided. The Heath Company assumes no responsibility for the operation of the completed instrument, nor liability for any damages or injuries sustained in the assembly or operation of the device.

HEATH COMPANY
Benton Harbor, Michigan

BIBLIOGRAPHY

The Radio Amateur's Handbook, A. R. R. L.
Antenna Book, A. R. R. L.
Nilson and Hornung; Practical Radio Communication

PARTS LIST

HEATHKIT AMATEUR TRANSMITTER

MODEL AT-1

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-3	1	100 Ω 1/2 watt
1-16	1	4.7 KΩ 1/2 watt
1-26	1	100 KΩ 1/2 watt
1-43A	1	51 Ω 1 watt 5%
1-17A	1	100 Ω 1 watt
1-11B	1	22 KΩ 2 watt
1-10B	4	47 KΩ 2 watt
Condensers		
20-29	1	15 $\mu\mu$f 500 volt mica
20-30	1	22 $\mu\mu$f 1 kv silver mica
20-31	2	68 $\mu\mu$f 1 kv silver mica
20-11	3	100 $\mu\mu$f 500 volt mica
20-32	1	100 $\mu\mu$f 1 kv mica
20-33	7	.001 μfd 500 volt mica
23-15	1	.5 μfd 400 volt paper
26-~~14~~ 21	2	50 $\mu\mu$f variable
25-22	4	8 μfd 350 volt electrolytic
Switches		
60-1	2	SPST slide switch
63-52	1	3 pole 3 position rotary
63-53	1	2 pole 3 position rotary
Transformers-Coils-Chokes		
54-21	1	Power transformer
46-7	1	Filter choke
45-4	2	1.1 MH RF choke
45-7	1	90 μh RF choke
40-32	1	Oscillator coil
40-33	1	80 M amplifier coil
40-34	1	40 M amplifier coil
40-35	1	20 M amplifier coil
40-36	1	10 M amplifier coil
Tubes-Meters		
407-21	1	10 MA meter
411-2	1	5U4G tube
411-8	1	6L6 tube
411-53	1	6AG7 tube
Sockets-Terminal Strips		
431-2	1	2 Lug terminal strip
431-3	2	3 Lug terminal strip
431-5	1	4 Lug terminal strip
434-38	1	Crystal socket
434-39	5	Octal tube socket
436-4	1	Phone jack
436-5	1	Coaxial jack
438-6	1	Octal plug
438-9	1	Coaxial plug
Hardware		
73-1	2	3/8" rubber grommet
208-2	4	Spring clip
250-8	10	#6 sheet metal screw
250-9	24	6-32 round head screw
~~250-7~~	~~4~~ 1	~~6-32 x 3/16 screw~~
250-18	4	8-32 round head screw
250-34	5	4-40 round head screw
252-3	24	6-32 hex nut
252-4	4	8-32 hex nut
252-7	~~3~~ 5	Control nut
252-15	5	4-40 hex nut
253-10	~~3~~ 5	Control washer
254-1	25	#6 lockwasher
254-2	4	#8 lockwasher
254-4	~~2~~ 4	Control lockwasher
259-1	3	#6 solder lug
250-22	2	Set screw
Miscellaneous		
89-1	1	Line cord
90-22	1	Cabinet
200-M49	1	Chassis
203-~~M45F58~~	1	Panel -M70F58 203-~~M700F58~~
204-M47	1	Coil bracket
261-1	4	Rubber feet
340-1	1	length #14 bare wire
340-3	1	length #16 bare wire
344-1	1	roll Hookup wire
346-1	1	length Spaghetti
462-M11	2	Pointer knob
462-15	2	Round skirt knobs
595-64	1	Manual